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STATEMENT OF WORK AND TECHNICAL REQUIREMENTS

ANNEX, A

SATELLITE SYSTEM REQUIREMENTS

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METOP Project Manager
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A.1 INTRODUCTION

A.1.1 SCOPE

ESA, in the frame of the METOP Preparatory Programme and EUMETSAT, in the frame of the EPS Programme, are jointly undertaking the development of a European polar orbit satellite system for operational meteorology and climate monitoring. This system is intended to complement the NOAA POES System.

The present document establishes the requirements for the METOP-1 satellite system which apply to the industrial proposal to be established for the System Phase B. It is anticipated that this document will be the basis for implementation (Phase C/D) of the METOP-1 programme, subject to changes resulting from the work carried out in Phase B.

Where the term "system" is used in this document, it shall be taken to mean the METOP-1 satellite system including its interface to the Ground Segment as well as to the launch vehicle. It shall not, unless otherwise specifically stated, be taken to include the EPS Ground Segment which does not form part of the present requirements.

A.1.2 MISSION BACKGROUND AND OBJECTIVES

A.1.2.1 Introduction

METOP-1 will fulfil a combined operational meteorological and climate monitoring mission in a polar low earth orbit. It provides the complement to the ENVISAT mission and completes the mission objectives of the original POEM-l mission. METOP-1 shall be launched end-2000 and will fulfil the European commitment to provide the "morning" service for operational meteorology, replacing the long standing service from NOAA POES. NOAA will continue with their existing "afternoon" service.

METOP-1 will form part of EUMETSAT's EPS system. In this, EUMETSAT is responsible for the definition of the overall system and the development of the operational ground segment, the procurement of the launch services and the execution of the operation phases, including recurrent satellites. ESA, in addition, is being responsible for the development of the Space Segment, develops an applications ground segment.

A.1.2.2 Mission Outline

The METOP-1 mission addresses two main objectives:

- to ensure continuity, improvement and availability for operational purposes of meteorological observations from the "morning" polar orbit;
- to endow Europe with an enhanced capability for the routine observation of the Earth from Space for long-term climate monitoring.

The Onerational Meteorology mission responds to the European commitment towards NOAA, to replace the "morning" service of the POES system, by providing an instrument complement which matches that carried by the "afternoon" service from NOAA. In addition an advanced infra-red sounder will be embarked which will provide improved pre-operational data to the operational meteorological community.

The Climate Monitoring mission is intended to fulfil requirements related to the global study and monitoring of the Earth's climate system as expressed by international co-operative programmes such as GCOS, IGBP and WCRP. This second objective is complementary to the climate monitoring provided by ENVISAT.

In addition to the two main objectives, METOP-1 may have the additional missions of providing a humanitarian service (Search and Rescue) and a space environmental monitoring function. These additional missions are treated as options, within the present Phase B definition.

A.1.2.3 Missions Beyond METOP-1

It is intended that, as part of the EUMETSAT EPS programme, a recurrent model of METOP-1, METOP-2, will be procured. Together, METOP-1 and METOP-2 will assure an operational service over a 10 year period.

METOP 1 and METOP 2 will be identical.

It is further intended that the EPS programme will be extended further, and other recurrent models will be procured to cover, probably a further 10 years.

The content of this extended programme, as well as the degree of recurrence of the satellites, remains to be determined.

A.2 DOCUMENTS

A.2.1 CONTEXT OF SATELLITE SYSTEM REQUIREMENTS

The present document, the Satellite System Requirements Specification, defines the technical requirements for the METOP-1 satellite. These requirements are defined within the frame of ESA and EUMETSAT agreements, as well as agreements between ESA and/or EUMETSAT and other partner organisations, which serve to define the EPS system which encompasses METOP-1.

These agreements are not directly applicable to the present document except where specifically identified, however it is the Agency's intention to ensure a full coherence of the requirements.

A.2.2 APPLICABLE DOCUMENTS

The following documents are applicable to these requirements to the extent specified herein. Where conflicts arise between the applicable documents and this specification then the indicated order of precedence shall apply.

For conflicts between this document and applicable documents identified as "equal level", then the conflict shall be brought to the attention of the Agency for resolution.

The latest issue of the applicable document shall pertain unless otherwise identified.

(Note: Applicable Product Assurance documents are listed in Annex B.)

A.2.2.1 Higher Level Documents

AD1		The Contract
AD2	MO-WS-ESA-PM-0022	The Statement of Work

A.2.2.2 Equal Level Documents

AD3	MO-RS-ESA-PA-0024	Product Assurance Requirements (Annex B of SOW)
AD4	MO-IS-ESA-SY-0025	Satellite/Ground Segment Interface Requirements (Annex C of SOW)
AD5		Ariane 4 Users Manual
AD6		Ariane 5 Users Manual
AD7	CCSDS-301.0-B-1	CCSDS Unsegmented Time Code Standard
AD8	ESA-PSS-04-107	Packet Telecommand Standard
AD9	ESA-PSS-04-106	Packet Telemetry Standard
AD10	ESA-PSS-04-105	Radio Frequency and Modulation Standard
AD11	ESA-PSS-04-104	Ranging Standard
AD12	ESA-PSS-04-100	Advanced Orbiting Systems, Network and Data Standards
AD13	ESA-PSS-04-151	Telecommand Decoder Specification
AD14	ESA-PSS-01-301	Derating Requirements and Application Rules for Electronic Components
AD15	ESA-PSS-01-401	ESA Fracture Control Requirements
AD16	MSFC-DWG-20M02540	
AD17	TBD	HRPT/LRPT Requirements
AD18	TBD	Encryption Requirements
AD19	EPS/MCP/SPE/92005	RF Equipment for DCS and S&R
AD20	NASA SSP 30425	Space Station Program Natural

		Bnvironment Definition for Design
AD21	UAG-82	International Reference Ionosphere, IRIS6
AD22		Goddard Earth Model (GEM-T1)
AD23		World Geodetic Standard 84 (WGS84)
AU24	MIL-STD-1750A	Military standard Sixteen Bit Computer Instruction Set Standard
AD25	MIL-STD-454M	Standard General Requirements for Electronic Equipment
AD26	NASA TM-82478	Space and Planetary Bnvironment Criteria
AD27	RS-CSG/Ed No.3(1)	Reglements de Sauvegarde - Safety Regulations
AD28	MIL-STD-1576	Elcctro-explosive Subsystem Safety Requirements and Test Methods for Space Systems
AD29	ESA-PSS-05-O	ESA Software Engineering Standards

A.2.2.3 **Lower Level Documents**

AD30	MO-RS-ESA-MI-0018	MIMR Instrument Requirements Specification
AD31	MO-RS-ESA-SC-0019	ASCAT Instrument Requirements Specification
AD32	SPE 1211368015	Bnvisat Avionics Interface Specification, Iss. 2, Rev. B
AD33	SPE 1228361-000	Polar Platform EMC Requirements Specification
AD34	MMS/MET/TN/JLD/160.94	Instrument interface Control Dooument TBC
AD35	PO-RS-DOR-PL-0008	Software Bngineering Standards
AD36	MO-DS-ESA-MI-0001	MIMR Instrument Interface Specification for a Generic Spacecraft
AD37	CD/1945/CMM	Interface Control Document between the Data Relay System and the Polar Platform

A.2.3 **REFERENCE DOCUMENTS**

These documents are to be considered as guidelines where called up.

RD1	GSFC-S-480-77	Low Resolution Picture Transmission and High Resolution Picture Transmission (LRPT/HRPT) General Specification
RD2	EPS/MCP/SPE/92001	Specific Requirements to HRPT and LRPT for EUM Polar Mission
RD3	EPS/GRE/REQ 93002	EPS Ground Segment Technical Specification
RD4	EPS/MHS/SPE/93002	MHS Interface Control Document
RD5	UIISGE-IS-2617547	AMSU Al Unique Instrument Interface Specification
RD6	UIISGE-IS-2624483	AMSUA2
RD7	UIISGE-IS-20029950	AVHRR/3
RD8	UIISGE-IS-2265780	HIRS/3
RD9	UIISGE-IS-3267402	DCS
RD10	UIISGE-IS-3267401	S+R Processor
RD11	UIISGE-IS-2295546	S+R Repeater
RD12	UIISGE-IS-3267400	SEM
RD13	ESA-PSS-04-108 (draft)	Advanced Orbiting Systems, Network and Data Standards
RD14		Marshal Engineering Thermosphere (MET)

		Model
RD15	IS-3267415	ATN-KLM General I/F Spec.
RD16	IA-TN-I.O.I.-61-IPT	IASI Instrument Data List
RD17	PO-TN-ESA-SCA-0072	ScaRaB Data List
RD18		Ozone Monitoring Instrument Announcement of Opportunity
RD19	SP-7-1	DRS Satellite Performance Specification
RD20	MSFC-SPEC-250	
RD21	MIL-BDBK-SD	Metallic Materials and Elements for Aerospace Vehicle Structures
RD22	MIL-BDBK-17A	Polymer Matrix Composites
RD23	MIL-BDBK-23A	Structural Sandwich Composites
RD24	PP.LI.ALS.MI.001	MIMR Interface Data List, 31 August 1991
RD25	ESA SP 1138	The Multifrequency Imaging Microwave Radiometer Instrument Panel Report

A.3 MSSION ASSUMPTIONS

A.3.1 MISSION PHASES

The phases of the METOP mission are identified in the following Sections. The design of the Satellite shall be compatible with these phases, taking account of the constraints induced by the launcher and the number and visibility of ground stations.

A.3.1.1 Launch and Barlv Orbit Phase(LEOP)

The LEOP shall include the following events, starting at the switch-over from ground-supplied power to the Satellite internal batteries:

- Internally powered pre-launch phase, during the count-down;
- Launch phase, from the launch itself until the separation of the Satellite from the launcher;
- Acquisition phase, including:
  - Attitude rate reduction, coarse attitude acquisition, fine attitude acquisition;
  - Solar array deployment and eventual start of rotation;
  - Instrument and other appendage deployment;
- Orbit correction phase, in which the rnanoeuvres from the injection orbit to the nominal orbit are performed;
- Initial switch-on, in which communication is established between the Command and Control Subsystem (CCS) and other Satellite subsystems;
- Payload functional check-out, in which the basic functions and health of the payload is verified.

A.3.1.2 Commissioning Phase

The Commissioning Phase shall have a nominal duration of three months, during which the payload shall be brought into a fully operational state in which the performances and measurement quality are known and controlled. Relevant adjustments may be made to the payload operational parameters or software to optimise performance. Specific activities shall include:

- Calibration of instruments;
- Verification of instrument measurements;
- Characterisation of instrument performance;
- Optimisation of on-board operations.
- Geophysical validation of products (not under Contractor responsibility)

A.3.1.3 Routine Phase

During the Routine Phase the instruments shall operate nominally, except during major orbit manoeuvres. Modification of payload operating parameters or software is not foreseen during the Routine Phase.

A.3.1.4 Emergency Phase

In the case of major failure which could endanger the survival of the Satellite the following sequence is foreseen:

- On-board anomaly or failure detection;
- Automatic transition to a survival mode;
- Ground diagnosis during subsequent ground station passes;
- Recovery to the Routine Phase under ground control.

A-3.1.5 Disposal Phase

The Disposal Phase will occur at the end of the Satellite operational life. During this phase METOP shall be made safe by venting all remaining on-board fuel.

A.3.2 OPERATIONAL ENVIRONMENT

Information on the METOP ground segment is provided in RD3.

A.3.3 INTERFACE ASSUMPTIONS

A.3.3.1 Launch Facility

Interface to the facilities to the launch site are defined in ADS andAD6.

A.3.3.2 Launch Vehicle

Interface to the Launch Vehicle is defined in Section A.4.7.

A.3.3.3 Ground Segment

Interface to the ground segment is defined in AD4.

A.3.4 PAYLOAD COMPLEMENT

The METOP-1 payload complement shall be as defined in Tables 3.4.1 and 3.4.2.

The detailed requirements per instrument are defined in Section A.5 of this specification.

Where options are identified for instruments, details are provided in AD2 for the relevant tasks.

Payload Item	Mission	Furnished by
Advanced Very High Resolution Radiometer (AVHRR/3)	Global Imagery, Global Sounding; Ocean Meausrements (SS), Clouds and Earth Radiation Budget, Land Measurements.	NOAA (ESA CFI)
High Resolution Infrared Sounder (HIRS/3)	Global Sounding; Atmospheric Minor Constituents (Ozone).	NOAA (ESA CFI)
Advanced Microwave Sounding Unit/A (AMSU-A1, AMSU-A2)	Global Sounding; Sea Ice.	NOAA (ESA CFI)
Microwave Humidity Sounder MHS)	Global Sounding; Cloud and Earth Radiation Budget, Sea Ice.	EUMETSAT (ESA CFI)
Advanced ARGOS DCS-2	Data collection and location; Collection of Climate Data.	NOAA/CNES (ESA CFI)
Infrared Advanced Sounding Interferometer (IASI)	Global Sounding (Improved Sounding Capability); Ocean Measurements (SST), Clouds and Earth Radiation Budget, Atmospheric Minor Constituents, Land Measurements.	CNES/ASI (ESA CFI)
Search and Rescue (S&R) [a]	Humanitarian Mission.	NOAA (ESA CFI)
Space Environment Monitor (SEM) [a]	Monitoring of the local Spacecraft Radiation Environment.	NOAA (ESA CFI)

[a] Not in the baseline

Table 3.4.1a: Payload Complement and Mission

Climate Instrument	Mission	Furnished by
ASCAT (Advanced Scatterometer)	Ocean Measurements (surface stress and surface wind)	Part of METOP-1 Programme
MIMR (Multifrequency Imaging Microwave Radiomter)	Ocean Measurements (SST), Land Measurements (Snow Cover, Soil Moisture, Sea Ice (extent), Cloud and Earth Radiation Budget (Cloud Liquid water) Precipitation (Parameterisation)	Part of METOP-1 Programme
Ozone Monitoring Instrument	Atmospheric Minor Constitutents (Ozone content and Profile, minor constituents).	NIVR/ASI (ESA CFI)
ScaRaB (Scanner for Radiation Budget)	Cloud and Earth Radiation Budget (Clouds, Radiation Budget, Albedo)	CNES (ESA CFI)

Table 3.4.1b: Payload Complement and Mission

A.3.5 LIFE TIME, AVAILABILITY AND RELIABILITY

A.3.5.1 Life Time

The satellite shall be designed for a nominal life term in orbit of 5 years following an on-ground storage of 5 years (under conditions to be specified by the Contractor).

The in-orbit lifetime refers to the capability of the satellite to provide sufficient resources to ensure orbit and attitude control, payload operation and payload data transmission over the specific period. The factors affected include consumables and life limited items (fuel, solar array output power, thermal control surfaces, lubricated mechanisms, high power tubes, high voltage power supplies). A margin of at least 1 year shall be included in the dimensioning of these elements.

Reliability/availability requirements are not considered in the life time specification.

A.3.5.2 Availability

The satellite will be designed to provide an in-orbit availability of greater than 97.5% TBC over the life time, after commissioning.

The definition of the availability is taken as the probability of the satellite and satellite to ground links providing all the required measurement data to the ground segment, and therefore includes the effects of manoeuvres required for orbit control and maintenance as well as link outages due to, e.g., atmospheric effects. The requirement includes the effects of cosmic ray induced single event upsets.

Reliability requirements are not to be considered in the availability specification.

Outages caused by CFE shall not be considered.

In-flight operational anomalies due to operational error or ground station malfunction or non-availability are not included in this specification.

A-3.5.3 Reliability

The satellite shall provide the nominal required support to the payload instruments with a probability of 752 over the specified life, including the launch phase.

Further, for Contractor Procured instruments, they shall individually provide a nominal performance with a probability of 80% (TBC) over the specified life.

These requirements exclude the reliability of the launcher and separation systems, and the ground segment or operational procedures. Failures (of redundant elements) are permitted within these definitions.

A.4 GENERAL SATBLLITB REQUIREMENTS

A.4.1 DEFINITIONS

The following definitions shall apply:

Satellite consists of the Platform and Payload Module.

Platform is equivalent to the Service Module (which contains power supply/storage, AQCS, Propulsion, Central CCS system inclusive TT&C).

Payload Module consists of the payload supporting hardware: structure, thermal control, power distribution and payload data management.

Pavload consists of Payload Module and Instruments.

A.4.2 PAYLOAD MODULE (PLM) AND PAYLOAD ACCOMODATION

A.4.2.1 General Requirements

The functions of the PLM are

- provide structural support to all instruments during launch and in orbit
- ensure nominal operation in all modes
- transmit acquired measurement data to ground segment

The necessary subsystems to provide these functions are

- PLM structure (Payload Carrier including specific interface hardware)
- PLM Thermal Control (internal units and instruments)
- PLM Data Handling Subsystem (LRPT/HRPT, X-band, data storage, multiplexing, formatting, encoding)
- PLM Command and Control (bus system and interfaces)
- PLM Electrical Power Subsystem (control and distribution)

Additionally the antenna, associated RF equipment and harness for the DCS shall be provided by the Contractor, according to AD19.

A.4.2.1.1 Interfaces PLM/instruments

Interface boundaries between PLM and instruments are as given by the instrument ICDs and definition in RD15. The physical interface is at the mounting flanges/pads at the instrument and the power/data connectors). Deployment devices needed for antennae are interface hardware. Bus couplers to connect spacecraft data/command and timing buses and networks with individual instruments shall be part of the PLM, even if installed physically in or on the instrument.

A-4.2.1.2 Interface8 PLM/Platform

Hardware accommodated on the PLM which performs tasks in the scope of the platform (e.g. AOCS sensors such as

earth and sun sensors, part of thrusters and related piping, hold down points of the Solar Array, gyro package) shall be treated as part of the platform.

Hardware accommodated on the platform which performs tasks in the scope of the payload (e.g. instruments, antennas) shall be treated as part of the payload if connected to the electrical interfaces of the PLM.

A.4.2.2 Payload Module Design Requirements

The PLM shall meet the requirements of Section A.4.9, Section A.4.10 and Section A.4.11.

The PLM shall be designed to be geometrically, structurally, and thermally decoupled from the platform, to the extent possible. It shall ideally form a functionally self contained unit with minimum electrical, mechanical, and thermal interfaces to the platform, so as to ensure that the PLM can be assembled, integrated, and tested as far as possible and transported independently from the platform.

The design of the PLM shall be modular at the level of the various payload components (including instruments and instrument subassemblies) with well defined and minimal interfaces so as to simplify system level tasks of transport, integration and testing.

The PLM mass properties (mass distribution and CoG) in launch and flight configurations shall be compatible with those platform requirements which guarantee launcher compatibility and attitude control performance.

The PLM configuration should present minimum interferences, as far as possible, with the thrusters and antennae fields of view and ensure an unobstructed field of view for the platform attitude sensors, and the sensors and radiators of the instruments, for all mission phases.

A.4.2.3 PLM Structure

The PLM structure shall provide:

- adequate access to PLM equipment, electronic boxes, test points and connections and their mounting interfaces for maintenance, mounting and demounting
- attachment points to satisfy PLM to platform interfaces
- provide adequate stability with respect to setting and creep phenomena in order to keep the relative alignment between attitude sensors, actuators and the instruments within the limits derived from the attitude measurement accuracy and the mission requirements
- alignment references as required to satisfy instruments and platform alignment
- mathematical models for the structural analysis of the PLM shall be compatible with that of the platform to allow easy combination into an overall spacecraft model
- Materials used for the structure shall be selected on the basis of overall system optimisation, ease of manufacture

A.4 GENERAL SATELLITE REQUIREMENTS

A.4.1 DEFINITIONS

The following definitions shall apply:

Satellite consists of the Platform and Payload Module.

Platform is equivalent to the Service Module (which contains power supply/storage, AOCS, Propulsion, Central CCS system inclusive TT&C).

Payload Module consists of the payload supporting hardware: structure, thermal control, power distribution and payload data management.

Payload consists of Payload Module and Instruments.

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- PLM Thermal Control (internal units and instruments)
- PLM Data Handling Subsystem (LRPT/HRPT, X-band, data storage, multiplexing, formatting, encoding)
- PLM Command and Control (bus system and interfaces)
- PLM Electrical Power Subsystem (control and distribution)

Additionally the antenna, associated RF equipment and harness for the DCS shall be provided by the Contractor, according to AD19.

A-4.2.1.1 Interfaces PLM/instruments

Interface boundaries between PLM and instruments are as given by the instrument ICDs and definition in RD15. The physical interface is at the mounting flanges/pads at the instrument and the power/data connectors). Deployment devices needed for antennae are interface hardware. Bus couplers to connect spacecraft data/command and timing buses and networks with individual instruments shall be part of the PLM, even if installed physically in or on the instrument.

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A.4.2.1.1 Interfaces PLM/instruments

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A.4.2.1.2 Interfaces PLM/Platform

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- attachment points to satisfy PLM to platform interfaces
- provide adequate stability with respect to setting and creep phenomena in order to keep the relative alignment between attitude sensors, actuators and the instruments within the limits derived from the attitude measurement accuracy and the mission requirements
- alignment references as required to satisfy instruments and platform alignment
- mathematical models for the structural analysis of the PLM shall be compatible with that of the platform to allow easy combination into an overall spacecraft model
- Materials used for the structure shall be selected on the basis of overall system optimisation, ease of manufacture

(and cost), EMC and AIV aspects, thermoelastic deformations and other factors to be defined by the Contractor.

A.4.2.4 PLM Thermal Control

The PLM thermal control design shall provide the PLM elements with the required temperature environment to ensure reliable performance during the required lifetime. It also shall satisfy alignment and collocation restrictions imposed by the instruments. In particular instrument requirements for radiation cooling shall be taken into account.

The PLM shall be decoupled thermally (radiative and conductive) from the platform to the best extent possible.

Mathematical models for thermal analysis of the PLM (including instruments) shall be compatible with that of the platform to be easily combined into an overall spacecraft model.

The material selection and detailed design for the PLM thermal control shall take into account other requirements such as EMC.

A.4.2.5 PLM Electrical Distribution

The PLM Electrical Power Subsystem shall meet the requirements of Section A.4.9.

A.4.2.6 PLM Data Randling

The Payload Data Handling Subsystem shall meet the requirements of Section A.4.5.

A-4.2.7 Payload Accommodation

The PLM shall have flat exterior walls to maximise instrument mounting locations but permit smooth load path transitions.

The PLM shall present as large a volume as possible to internally accommodate high power electronics (preferred at the outer walls) and low power electronics (shear walls if needed). Margins in volume shall be identified whenever possible in order to allow the accommodation of optional instruments.

The locations of instruments and internal and external PLM equipment (antennae, deployment mechanisms) shall be optimised with respect to unobstructed optical and thermal fields of view (between instruments as well as by deployed antennae), co-alignment requirements for instruments, electromagnetic interferences, thermal loads for different modes, mass distribution and balance, harness guidance and minimisation of losses in RF and power lines, grounding.

Provisions shall be taken to accommodate units on or in the PLM which functionally are a part of the platform (AOCS sensors, thrusters and piping, hold down points for solar array, gyro package, as required).

A.4.3 ORBIT AND ATTITUDE REQUIREMENTS

A.4.3.1 Orbit

A.4.3.1.1 **Reference Orbit**

METOP shall be able to operate in the following reference orbit for the overall duration of the mission

- Type: Near-Polar Sun-Synchronous
- Repeat Cycle: 5 days
- Mean Local Solar Time: 09:00 h TBC
- Longitude of Ascending Node: 0.0 deg
- Cycle Length: 71 orbits

The orbital parameters for this reference orbit, with respect to inertial frame Mean-of-Date System 52000.0, are:

- Semi-Major axis: 7197.939472 km
- Eccentricity: 0.001165
- Inclination: 98.704663 deg
- Right Ascension of Ascending Node: 55.835595
- Argument of Perigee: 90.00000 deg
- Mean Anomaly: 270.133359 deg
- Date: 1 Jan 2000
- Time 0.875015 (fraction of Julian day)

A.4.3.1.2 **Operational Orbits**

In addition to the reference orbit, defined in Section A.4.3.1.1, METOP shall be capable of operating in all sun-synchronous orbits with semi-major axes in the range 7169.059 to 7217.355 km (corresponding to altitudes at ascending node of 796 to 844 km) TBC.

A.4.3.1.3 **Orbit Tolerance**

The reference orbit of Section A.4.3.1.1 shall be maintained, by means of orbit measurements and manoeuvres calculated by the ground segment, within the following tolerances over the whole mission lifetime:

- Mean Local Solar Time: +/- 5 mine (TBC).
- The ground track of METOP traced on the earth never to deviate by more than +/- 5 km (TBC) from the ground track corresponding to the ideal sun-synchronous orbit, at the selected reference altitude.

Note: the ground track is the sub-satellite point with METOP executing local normal pointing (defined in Annex H), excluding pointing errors.

Computations of drag shall assume the F10.7 and Ap values defined in Section A.4.0.3.1.1

Orbit maintenance shall be achieved as far as possible by mean5 of in-plane manoeuvres.

The requirements of this paragraph may be relaxed following the evolution of operational requirements. However the Contractor shall use these requirements as the design case.

A.4.3.1.4 Orbit **Maintenance Manoeuvres**

METOP shall be able to operate in the reference orbit, and execute orbit maintenance as above, without deviating from specified payload support and performance requirements defined in this document. This does not apply to out-of-plane manoeuvres required for inclination control.

A.4.3.1.5 Orbit State **Vector**

METOP shall provide information in the downlink from the PDHS which shall enable ground stations to restitute the ground location of measurements. This shall, nominally, be performed by including, in the science telemetry, an appropriate ascending node state vector, as well as time correlation information required to synchronise on-board time to DTC. These data shall be assumed to be uplinked from the TT&C ground station in advance. The processing of this information to provide the ground location information is the responsibility of the individual ground stations. In the case that a GPS system is embarked (see "OPTIONS", Section A.9) then the processed position and time information from the GPS system shall be downlinked at a 1Hz (TBC) resolution.

In this case (GPS Option) the platform shall generate and distribute to the payloads and to ground, a time-tagged orbit state vector, expressed in Cartesian elements, with an update frequency of 1Hz. The orbit state vector shall be available at the instrument interface not earlier than, and not later than one second after, its validity.

A.4.3.1.6 Day/Night **Flags**

Time-Tagged &y/night flags shall be provided by the platform to the payload and to ground.

Equator-crossing flags may also be required (TBC).

The flags shall be available at the instrument interface not earlier than 2 seconds and not later than one second before their validity.

A.4.3.1.7 Orbit Prediction **(TBC)**

It shall be assumed that orbit prediction data over a subsequent 24 hours shall be provided by the ground segment within the following accuracies:

3 Sigma Accuracy	Position (m)	Velocity (m/s)
Radial	30	0.955
Along-Track	920	0.029
Across-Track	15	0.016

A.4.3.2 **Attitude Control and Measurement**

A-4.3.2.1 Yaw Steering

METOP shall provide a yaw steering capability (usually called Yaw Steering Mode, YSM) which shall continuously align a main longitudinal reference axis along the ground track vector as traced by the MRTOP sub-satellite point on the earth, instead of aligning it with the flight vector in orbit.

It shall be possible to activate/deactivate yaw steering once per orbit.

The platform shall provide a flag to ground giving the state of the yaw steering.

Yaw steering is further described in Annex H of the SOW.

A.4.3.2.2 Ruth Pointing Attitude

METOP shall, in all operating orbits, continuously maintain an ideal earth-pointing attitude with the following characteristics:

- the nominal earth viewing direction is the Local Normal Vector from MRTOP, with respect to earth as defined by the reference ellipsoid WGS84, with equatorial radius 6378.137 km and oblateness coefficient f = 1/298.257223563.
- when yaw-steering is off, a main axis of MRTOP shall be aligned with the ideal flight vector, i.e. in the idealized orbit plane. This shall be called Fine Pointing Mode, FPM.

A-1.3.2.3 Adjustment of Control Loops

METOP shall permit modification of the attitude control loops by software updates in orbit. METOP shall, for this purpose, be capable of transmitting, on demand from ground, attitude control loop instrumentation data sufficient for on-ground reconstruction of attitude control loop characteristics and satellite disturbances.

In addition to the above, it shall be possible to adjust the bias pointing of the satellite (through ground command) by up to 0.5 degrees about each satellite axis.

A.4.3.2.4 Attitude Error Cone

Angular rates on separation from the launcher, and the Contractor-defined LEOP sequence of Rate Reduction Mode and Coarse Acquisition Mode, shall result in an attitude error cone about the nominal operational attitude. The Satellite shall be designed to be compatible with this condition.

A.4.3.2.5 Attitude **Tolerances**

The following definitions of attitude terms shall be used:

Pointinq accuracy is the deviation of the actual pointing vector from the ideal pointing vector, at any instant.

Pointinq stability is the algebraic difference between the greatest and smallest instantaneous deviation of the pointing vector in a given time window.

Pointinq rate accuracy is the difference between the instantaneous rate of change of the actual pointing vector and the rate of change of the ideal pointing vector at the same instant.

For the nominal pointing vector one operational case
local vertical

A.4.3.2.5.1 Pointinq Performance

each ____________________

Satellite Axis	**Pointinq Requirement (deq)**
Pitch	0.120
Roll	0.120
Yaw	0.150

Contributing parameters to the mispointing shall be combined using the rules defined in Annex H of the SOW.

A.4.3.2.5.2 Nominal Pointinq Knowledge

The following pointing knowledge tolerances between the nominal attitude and the attitude of each pavload instrument interface are allowed.

Satellite Axis	**Knowledge Requirement (deg)**
Pitch	0.120
Roll	0.120
Yaw	0.150

Contributing parameters to the pointing knowledge shall be combined using the rules defined in Annex H of the SOW.

A.4.3.2.5.3 Nominal Pointinu Rate Accuracy

The pointing rate about any axis at the instrument interface shall not exceed 0.003 deg/s.

This rate shall include all disturbance torques (internal and external) acting on the satellite, ageing over lifetime and distortions generated by the environment.

A.4.3.2.5.4 Pointino Stability

No requirement.

A-4.3.2.5.5 Pointinu Bxceotions

METOP shall maintain its nominal earth pointing mode as required for payload operations during orbit maintenance operations, with the following exceptions:

- Pointing errors are permitted to increase for small along-track manoeuvres during maintenance thrusting. Nominal pointing performance shall be regained within 2 minutes from the end of thrust.

- Pointing errors are permitted to increase for large orbit manoeuvres during maintenance thrusting. Nominal pointing performance shall be regained within 3 orbits from the end of thrust.

- Cut of orbit-plane manoeuvres may also be executed with an attitude deviating from an earth pointing requirement, provided they can be completely executed during eclipse, such that sensitive payload instruments do not become exposed to solar illumination or to albedo of the illuminated earth when METOP takes the non-nominal attitude.

A.4.3.2.5.6 Instrument Co-alionment

In orbit, AMSU A1/A2, HIRS, IASI and MHS are required to be co-aligned with respect to AVHRR. To achieve this, the relevant instrument interfaces shall maintain a relative mispointing, with respect to the AVHRR interface, of less than 0.020 deg about each axis (TBC).

A.4.3.2.6 AOCS Sizing

Following the launch of METOP, small orbital manoeuvres will be allowed so that unwanted torque disturbances generated during thruster firing (e.g. due to thruster mismatch) can be characterised. The use of such characterisation manoeuvres can be considered when sizing actuators (wheels).

Propulsion shall not be used for attitude control during nominal payload operations. AOCS sizing (wheels) shall be such that saturation shall not occur under extreme neutral atmosphere atmospheric environmental conditions. For the design case, for actuator sizing, the following values shall be assumed:

- Geomagnetic index Ap: 400
- Solar Flux F10.7: 370 (TBC)

A.4.3.3 AOCS Safe Mode

The Platform shall offer a sun pointing capability, which shall be an integral part of the Satellite Safe Mode (see Section A.4.4.2), such that, in this mode, the METOP +z axis always points towards the sun, within an error cone of 8 deg during sun-light phases. When leaving eclipse, the error cone angle may be up to 20 deg. but this shall be reduced to 8 deg within 500 sec from eclipse end.

In addition to the nominal operational configuration the Safe Mode shall be compatible with the following additional ASCAT configurations:

- both deployable ASCAT antennas stowed in their launch configuration;
- one deployable ASCAT antenna stowed in its launch configuration and the other latched in its nominal operational configuration.

If Safe Mode is invoked during a deployment it shall be possible to complete the deployment (through ground command) before full activation of the Safe Mode.

A.4.3.4 Depointing Signal

In FPM and YSM, METOP shall provide to the instruments a depointing signal, via a dedicated depointing signal line, DSL, whenever the satellite exceeds the nominal pointing by +/- 1 deg about any attitude axis.

This function shall be available even in the case of CCS failure.

The time between DSL activation and a satellite mode transition shall be compliant with the time the instruments need to reach a safe condition.

A.4.3.5 Initial Orbit Acquisition

METOP shall be able to acquire the initial operating orbit after separation from the Ariane launcher with the orbit injections errors, attitude angles and rates identified in AD5 andAD6, compensating for all nominal dispersions. These requirements apply for a launch at any time within the nominal launch window.

METOP shall be compatible with a launch window of 10 minutes every day.

The initial operating orbit shall be reached in less than 10 days after separation from the launcher.

A.4.3.6 Propulsion

METOP shall provide a propulsion system with which it shall achieve and maintain the reference orbit, defined in Section A.4.3.1.1, and other orbits as defined in Section A.4.3.1.2, within the required ranges, defined in section A.4.3.1.3. METOP shall have thrust and propellant storage capabilities for:

- Orbit acquisition, as defined in Section A.4.3.5.
- Maintenance of the operating orbit within specified ranges for 6 years.
- Support the derived requirements of Safe Mode (Section A.4.3.3) and other thruster AOCS modes (in the event of other failures).
- Inaccuracy in the fuel-gauging method.

The Contractor shall ensure that the plume impingement is within allowed contamination and satellite disturbance limits.

At the termination of the mission the satellite shall have the capability to expel all remaining fuel.

A method of fuel mass gauging shall be provided.

A.4.3.7 Instrument Deployments

Shock loads due to appendage or instrument deployment shall be compatible with the AOCS, active in one of its nominal operating modes (thruster or wheel) and with the solar array drive mechanism unlocked.

A.4.4 OPERATIONAL REQUIREMENTS

A.4.4.1 Satellite Nodes

The Satellite shall at all times be in a clearly identified state, or Mode, of both hardware and software. Transitions between modes shall be controlled, and allowed/non-allowed mode transitions identified. As a minimum, the following classes of modes shall be identified:

A.4.4.1.1 Launch Mode

The Satellite shall be in Launch Mode from the moment of transfer of power provision from ground to the on-board batteries, until the end of the initial activation and deployment sequence of the platform during the LEOP, with the solar array deployed and rotating and the reaction wheels unlocked.

A.4.4.1.2 Platform Nominal Modes

These modes correspond to the nominal operating mode of the platform where, following LEOP, it can provide all the services required in this requirement specification. This mode may be achieved with the nominal or redundant elements. Specific modes within this class shall be Yaw Steering Mode, Fine Pointing Mode, etc.

A.4.4.1.3 Payload **Nominal Modes**

Payload instruments shall provide well identified modes and mode transitions. Modes shall be unique and exclusive. As **a minimum,** the following modes shall be identified:

A.4.4.1.3.1 Payload Off Mode

In this mode the entire payload is off and maintained at survival temperature.

A.4.4.1.3.2 Payload Stand-Bv Mode

In this mode all payload management subsystems are operational (on and any relevant software running) but the instruments themselves are off.

A.4.4.1.3.3 Instrument Stand-By Mode

In this mode all payload management subsystems **are** operational **(on, and** any relevant software running) and all the instruments are in standby.

A.4.4.1.3.4 Measurement Mode

This mode corresponds to the nominal operating **mode** of the **payload.** Sub-modes shall be supported (e.g. calibration).

A.4.4.1.4 **Safe Mode**

Safe Mode shall be invoked in the following conditions:

- The platform avionics cannot achieve recovery after failure through the management of the available redundancy;
- The avionics itself have failed. Such failures shall be detected through high-level independent monitoring, such as depointing.

The specific requirements for Safe Mode are given in Section A.4.4.2.

A.4.4.2 **Safe Mode Requirements**

Safe Mode shall be implemented as far as possible independently from the nominal mode (hardware, software). In this mode the instrument command and control cannot be used and the platform cannot provide its required services to the payload.

It shall be sun-pointing, with the performances specified in Section A.4.3.3.

The payload shall be off with the instruments being set up so that they cannot suffer from depointing.

The payload shall not suffer irreversible damage. This shall be achieved by:

- Putting the payload off with the instruments in a safe state (e.g. shading sensitive apertures from sunlight);

- Provision by the platform of minimal resources as requested in the individual ICDs and in particular by providing a survival thermal control concept.

To allow the instruments to reach a safe state a signal shall be sent to the payload before it is shut off.

The Platform shall have instrumentation and TM/TC capability via omnidirectional TTCC links for permitting the ground to recover the Satellite for nominal operations by:

- downlinking with special telemetry any failure messages, out-of-limits, configuration status and last changes, software and computer memory dumps, which will enable ground operators to understand the failure events and to identify the involved hardware/software. For this reason, the memory content of Platform computer(s) shall not be lost when the Platform enters Safe Mode;

- receiving via the TC uplink, and executing any commands and software changes prepared by the ground for specific telemetry formats and any Platform configuration changes necessary for returning the Platform for nominal operations;

- providing in the meantime Survival resources to the payload.

A.4.4.2.1 **Safe Mode During LEOP**

In case of any critical failure in the initial in-orbit activation sequence METOP shall enter Safe Mode, from which it can be recovered by ground intervention. It shall survive in this mode, and supply survival resources to payload instruments as defined. The possible duration of safe mode shall only be limited by resources. See also the AOCS requirements on Safe Mode, Section A.4.3.3.

A-4.4.3 General Operability Requirements

In this Section A.4.4.3, requirements on instruments are either to be provided by the instruments themselves or externally by other sub-systems.

A.4.4.3.1 command and Control

The Satellite shall provide data management services to its payload and subsystems to allow the ground system to operate and control it in orbit and on the ground, in the different flight operating modes.

The status of the METOP Satellite shall be observable through its telemetry. The Satellite shall be fully controllable from ground as well as having autonomous functions, as specified in this document.

Metop shall accept and execute the following types of commands:

A.4.4.3.1.1 Macrocommands

These consist of data blocks for the On-Board Software (i.e. OBC, ICU, or secondary processors) as defined in AD32 and are split into:

- MTC: Time-Tagged or Immediate Macrocommands for Platform control

- IM-MCMD: Immediate Macrocommands for Payload Instruments control

- TT-MCMD: Time-Tagged Macrocommands for Payload Instruments control

"Immediate" means that the Macrocommands shall be executed immediately, allowing for delays due to defined on-board latencies. "Time-Tagged" means that the Macrocommand shall be executed at the instant of time specified in the relevant part of the Macrocommand header, within the specified allowed inaccuracies.

A.4.4.3.1.2 Single Commands

- DTC: Direct Telecommand for direct execution by the On-Board Telecommand Decoder

- XTC: Exclusive Telecommand for configuration of CCS registers (e.g. OBC) without participation of the OBC Software

- ITC: Immediate Telecommand for direct execution via the OBDH Bus (i.e.immediate single interrogation(s)).

A.4.4.3.2 Payload Command and Control

The payload instruments shall have access to the Control Subsystem (CCS) services of the Satellite, via standard interfaces and protocols. The CCS of MBTOP shall be transparent to the ground system during nominal flight operations, i.e. end items of the METOP systems and payload shall have logical addresses, in all ground to METOP communications. The METOP CCS shall be designed hierarchically, with all data/command traffic between the Platform and payload instruments being controlled by the Platform.

MBTOP sub-systems, instruments and equipment shall:

- be designed, so that no single malfunction of software or single instance of erroneous commanding can permanently damage or degrade hardware or its use.

- be designed so that it shall be possible to recover from modes achieved by corrective actions using normal macrocommands, i.e. without patching.

- provide a limited capability to generate non-nominal telemetry on *request.* This includes sampling sensors which are normally not fully contained in the down-link telemetry or altering monitoring rates and resolution.

A.4.4.3.3 Nominal Instrument Commandability

All instruments shall comply with the Command and Control Requirements and the OBDH and Measurement Data Protocol

Requirements of AD32 either directly or via an associated interface unit.

Instruments shall survive when operated as required by the Platform in ground phase, LEOP phase and during orbit maintenance. This includes safe mode and transitions into safe mode.

Nominal instrument commanding shall be performed using time-tagged macrocommande from the CCS.

Instruments shall be designed such that in nominal mission operation the requirement for receipt of macrocommands is infrequent.
Nominal instrument commanding shall not require a peak macrocommand rate of more than one macrocommand per 10 seconds (TBC).

Instruments shall monitor the execution of macrocommands and shall report successful and unsuccessful execution together with diagnostic information. This information shall form part of the instrument history recording capability. For instruments without an ICU this function may be provided externally.

A.4.4.3.4 **Instrument Observability**

On-board events and parameters shall be observable by the ground to allow proper operation. Reporting shall be such that continuity is ensured (no events lost) and accurate datation is provided.

Housekeeping shall be acquired sequentially according to a fixed order.

Instrument modes shall be observable via housekeeping data.

Beginning and ending of modes shall be observable and dated with a resolution of 4 msec.

Successful and un-successful execution shall be reported to ground.

Min/Max variations of housekeeping shall be recorded on-board and reported to ground. It shall be possible to select which housekeeping data are reported.

Exceeding parameters limits and re-entry into limits shall be recorded and reported to ground.

Autonomous switchdowns shall be observable by ground.

A.4.4.3.5 Instrument Autonomy

Instrument shall be designed for autonomous operation.

For commandability and observability under nominal conditions autonomy shall be ensured by time tagging the commands to be executed.

For non nominal and failure cases the instrument ICU and appropriate special hardware provisions shall be responsible for detecting malfunctions and taking appropriate actions.

The instrument shall autonomously:

- Detect malfunctions;
- Perform recovery actions for instrument safety;
- Provide visibility of malfunctions.

The instrument shall regularly monitor the status of any internal time counter against available time information from the Platform. Recovery action shall be taken in case of discrepancy.

Instruments shall not perform autonomous reconfiguration.

A-4.4.3.6 Payload Instruments Switch-Off

The Satellite shall provide a mechanism for switching off the METOP payload instruments directly by hardware.

The Satellite shall be able to switch off each of the instruments individually.

The switching off of payload instruments shall be executed as a result of a command from ground, an autonomous action initiated by the CCS, or directly upon request from the instrument in question.

The payload instrument(s) shall be warned in advance about the imminent switching off, except for the case where the switching is being performed upon payload instrument(s) request. The warning signal shall be a hard-wired Equipment Switch-Off Line (EQSOL), and shall be activated 60 seconds prior to the actual switch-off.

A.4.4.3.7 **ICU Requirements**

ICU's of all Contractor-procured instruments shall be based upon a processor fulfilling the MIL STD 1750 Instruction Set (AD24) unless there are strong and demonstrated reasons why this should not be the case.

Software of all ICU's shall be written in a single language to be chosen by the Contractor in accordance with Section A.7 of this document. A single set of standard software support tools shall be defined by the Contractor, in accordance with Section A.7 of this document, and used to produce software for all ICU software.

The memory usage, including patch and dump, of all ICU's shall comply with Section A.4.4.7.2.1.2.

A.4.4.4 Switch-on and Check-Out

A.4.4.4.1 Switch-On and Check-Out

METOP shall permit in-orbit switch-on, switch-off, initialisation, re-initialisation and check-out of all Platform and Payload Module subsytems:

- automatically, with override capability from ground;

- manually from ground.

Any switch-off eequenct shall end with a fully defined configuration status of all involved units and software, and any switch-on sequence shall be a controlled process starting from the defined configuration status.

A.4.4.4.2 Initial Switch-On Sequence

METOP shall start the initial switch-on sequence from launch vehicle event and/or separation signals without the need for ground commande, and shall automatically achieve switch-on to a permanent safe configuration in which the solar array is deployed, unlocked and rotating and with nominal attitude control.

A-4.4.4.3 **Deployments**

Deployment of payload appendages shall be initiated by ground command, and shall be performed during observation of the satellite by the LEOP ground stations.

A.4.4.S <u>On-Board Operations Management</u>

A.4.4.5.1 **METOP control and Operations**

It shall be possible, whenever METOP is in visibility from ground stations, to continuously monitor and control the Satellite from ground. The Satellite design shall be compatible with command and control from a single S-band ground station during routine operations. The Satellite shall be capable of operating autonomously for periods up to 36 hours.

A.4.4.5.2 **Manual Override**

The Satellite shall permit manual override or inhibit/enable of all automated functions individually, from ground.

Any such overrides/inhibits/enables shall for all functions of critical categories or whose loss or failure may result in catastrophic or hazardous consequences, be two-step operations with positive feedback confirming correct receipt of the override/inhibit/enable command prior to acceptance of the execute command.

A.4.4.5.3 C-d Check

The Satellite shall automatically check any received command for

- syntax, format;

The Satellite shall reject invalid, unauthoristd or unallowed hazardous commands, shall execute acceptable commands, and ehall report in the telemetry to ground the rejection, or the execution of the command, after verification of the eucctesful completion of the command activity, respectively ehall report a command execution failure if the completion is not achieved.

The Satellite instrumentation and monitoring capability shall permit the ground to observe in the telemetry any interim steps of execution of lengthy or complex commands or command sequences.

A.4.4.6 Monitoring Requirements

A.4.4.6.1 Housekeeping Data

The Satellite shall provide the necessary instrumentation, monitoring and downlink TM capability to allow the ground to determine at any time the precise and current status of all parameters of the flight configuration essential for flight operations from ground, including the configuration status of the redundant units, covering also Platform computer and software parameters. The instrumentation, monitoring and downlink capability shall cover all in-orbit phases, operating modes and configurations of the Satellite and its payload, including any orbit transfers and orbit maintenance, from launch vehicle separation onwards, and including Payload Off Mode and recovery sequences controlled by the Satellite fault processing and recovery system. Satellite housekeeping data shall be downlinked time-tagged in the Satellite telemetry.

The satellite telemetry requirements shall be fulfilled even when the satellite is operated using S-band telemetry only via one ground station per orbit; this implies an satellite internal history recording capability.

The log of Satellite events, anomalies etc. shall cover at least 36 hours and shall be downlinked on request from the ground.

The CCS shall be capable of monitoring up to 256 parameters from each of the payload instruments, typically at a rate of once every 16 seconds with the capability of increasing the sampling frequency of any parameter to at least 8 times per second.

The unambiguous interpretation of telemetry data shall be possible without knowing the history of telecommands.

A.4.4.6.2 HK Data Limit Checking

The Satellite shall execute mode and configuration-dependent limit check of parameters of its own systems and of payload instruments as necessary for system management and protection. It shall be possible to program an upper and lower limit for each monitored parameter, and to selectively modify, enable and inhibit these limits from ground. The Satellite shall report to ground in its telemetry all out-of-limit and inhibited conditions.

A.4.4.6.3 Downlinking of Data to Payloads

The Satellite shall downlink in its telemetry all data/information provided to payloads as required, such as orbit state vectors, flags and time information.

A.4.4.6.4 Verification of On/Off **Status**

METOP instrumentation and telemetry shall permit positive verification of the unit **level** ON/OFF relay status of de-activated equipment units.

A.4.4.7 <u>Command & Control</u>

Further to the Command and Control requirements implicit in Section A.4.4.1 to Section A.4.4.10, the following detailed requirements are identified.

A-4.4.7.1 **General Requirements**

A.4.4.7.1.1 <u>Time Taaaing</u>

All command types which are processed by the CCS shall have the possibility of being time-tagged

A.4.4.7.1.2 <u>command and Control Frame Format</u>

The **METOP** C&C Frame Format shall be compliant with the CCSDS standards for TM/TC, according to AD8 and AD9.

A.4.4.7.2 Functional **Requirements**

A.4.4.7.2.1 <u>Fliaht Confiauration Manaaement</u>

A.4.4.7.2.1.1 CCS Security Features

Security features and procedures shall be provided either on board or via the ground commanding procedures, for software and data which shall be protected from inadvertent/unauthorised access, change and distribution.

A.4.4.7.2.1.2 Memory Loading and Dumping

The Satellite shall permit dumping (RAM and ROM) of data and program code stored in any on-board computer and memory without interruption of nominal operations. At times of peak MTL activities this feature is not required.

The Satellite shall permit loading (RAM) of data and program code stored in any on-board computer and memory not involved in ongoing operations. At times of peak MTL activities this feature is not required.

At initialisation, software shall be downloaded from PROM to RAM. All software packages shall run out of RAM, except for the downloading function and Safe Mode software.

All RAM areas shall be accessible for patch and dump.

All PROM areas shall be accessible for dump.

If EEPROMs are selected by the Contractor they shall be accessible for patching.

A.4.4.7.2.1.3 CCS Instrument Switch-Off Signals

In case of METOP CCS failures occurring and preventing the use of the on-board CCS to command and monitor the payload instruments, the Satellite shall send to the payload instruments switch-off signals allowing an organised switch-off of these instruments.

A.4.4.7.2.1.4 Operations Support

The Platform shall execute time-tagged logging of events such as Payload and ground control inputs, system anomalies, error/fault messages, etc.

A.4.4.7.2.2 Macro Commands

Only a limited number of different high level macro-commands will be needed for operation of each payload instrument, such as on, off, standby, measurement modes, memory loads/dumps, etc. The macro-command expansion into detailed command sequences is done within the payload instrument.

The CCS shall provide serial digital data interfaces for sending uplinked high level macro commands and auxiliary data and collecting housekeeping TM between the Platform and the payload instrument processors.

Payload instruments shall accept these commands and shall send the housekeeping TM formatted to the ENVISAT on-board TM/TC protocol standard (AD32). The Contractor-procured instruments shall use the EWVISAT standard RBI ASIC MC1031.

k.4.4.7.2.3 Ancillary and Housekeeoins Data

The CCS shall provide to payload instruments time-tagged ancillary Platform data as specified in relevant sections of this document, through the same serial digital interfaces utilized for command distribution. Payload instruments will provide to the CCS instrument housekeeping data on this interface. This instrument housekeeping data shall also be included by the CCS into the Satellite housekeeping format, for transmission to ground. The Platform shall not occupy more than 50% of the total METOP housekeeping format, with the remainder available to instrument housekeeping, except if otherwise commanded from ground.

A.4.4.7.3 Satellite TT&C Link

A.4.4.7.3.1 Functional Reuuirements

The TT&C S/S shall provide an omnidirectional up and downlink on S-Band to and from the Ground Station for satellite command and monitoring specified in Annex C of the SOW.

The link to/from this Ground Station shall be available in all satellite mission phases and shall support range and range-rate measurements according to AD11.

The telecommand and telemetry protocols on S-Band shall be according the ESA standards AD0 and AD9.

Authentification of telecommands shall be performed in accordance with AD8 and AD13.

Simultaneous ranging, telemetry and telecommanding shall be possible from ground station.

The following data rates shall be supported on S-band:

- 2.000 kbps on the uplink
- 4.096 kbps on the downlink

A.4.4.7.3.2 TT&C Link Requirements

TT&C links shall be in accordance with Annex C (AD4).

A-4.4.7.4 Payload Management Buffer

The Satellite shall have an on-board capability for payload housekeeping data storage and time-tag macrocommand queue storage

- the total volume shall be at least 100 kbytes;
- it shall be possible to load this amount of software, macrocommand and/or data into this storage, via S-band uplink from ground;
- it shall be possible to load payload instrument computers from Payload data storage area, or inversely dump payload instrument computers into it.

A.4.4.7.5 CCS Data/C-d Transfers

The CCS shall execute all digital housekeeping and other relevant data (i.e. not scientific measurements data from instruments) and command transfers on-board, into and from the up/downlinks, as far as impacting the payload complement:

- preserving chronological sequences of packets from the same instrument, apart from recorder playback;
- without transmission delays except for delays due to time-tags;
- with a bit error rate for any digital processing and transfer end-to-end on-board better than 10^-9.

A.4.4.7.6 Discrete and Analog Signals

The CCS shall have the capability to acquire, separately from the OBDH, up to 32 (TBC) discrete level input signals and up to 32 (TBC) analog input signals from the payload. These data shall be included in the **METOP** housekeeping telemetry formats, and shall be monitored by the CCS if they pertain to parameters critical for **METOP** system management. This requirement is in addition to any payload thermistor sensing required by the Platform for instruments thermal control purposes.

A-4.4.7.7 Discrete Commands

The CCS shall have the capability to distribute separately from the OBDH up to 32 **(TBC)** discrete output commands for commanding of the payload. It shall be possible to activate these commands by using **macro-**commands **uplinked** from ground to **METOP**. This requirements excludes pyro commands.

A.4.4.8 **Fault Processing** and **Recovery Management**

A-4.4.8.1 **Fault** Detection

The Satellite in orbit shall automatically detect any faults, failures or errors which cause, or have the potential to cause, it to deviate from its commanded configuration and operating mode. As part **of** this capability there shall be features which detect deviations from nominal, in the software processes and in software to hardware compatibility, such as endless loops, improper transfers to software control, **CPU** overload etc.

A.4.4.8.2 **Fault** Recovery

The Satellite shall recover from failures/faults/errors within the Sallite in one of the following ways, in order of preference:

1 Continue nominal operations by immediately activating an available redundant functional path. Transient short-time interrupts, or exceedances of specified tolerances of payload support parameters are permissible.

2 If the redundant branch cannot be activated immediately, or if the failure requires re-configuration the payload or if the failure appears within a re-configuration sequence of the payload, the Satellite shall power down the payload except for survival resources, where required, but shall itself continue in a Payload Off Mode, in which the Satellite operates nominally, except for the powered-down payload and the particular failure mode. Minimum payload support as defined for the Safe Mode shall be provided.

3 If the switch-over to the healthy redundant branch or back-up does not lead to re-establishment of nominal operations or the Payload Off Mode, or if a healthy redundancy is no longer available, the Satellite shall achieve a Safe Mode as defined in Section **A.4.4.2.1,** before the Safe Mode performance parameters (e.g. attitude).

A.4.4.8.3 **Ground Identification of Failures**

For functions in reliability criticality categories, or functions whose loss or failure may result in catastrophic or critical hazard consequences, the Satellite shall have instrumentation and cross-strapping capabilities to permit the ground to:

- identify from telemetry before and after the failure, with the Platform in nominal operating mode, the failed item down to the level of the impacted functional path and the impacted redundant branch of this path;

- inhibit the automatic switch-over mechanism for this failed redundant branch;

- identify from telemetry the failed unit of the redundant branch and to utilise the healthy remainders of the functional path for reconstruction of a back-up mode for the function.

A.4.4.8.4 **Failure Reporting to Ground**

The Satellite shall report in its telemetry to ground the occurrence of the failure/fault/error and all mode and configuration changes executed in response to the failure event.

The Satellite shall generate and transmit to payload instruments a flag whenever a failure/fault/error is detected in the Satellite, which would impact the payload instruments (e.g. Safe Mode alarm signal and Depointing signal). The Satellite shall in its onboard event log enable the relationship to be made between the fault/error messages and automated procedures initiated in response to the messages. The Satellite shall avoid filling the log with repetitions of error/fault messages and related recovery reports which are not necessary for event investigation (for example messages repeated with every monitoring cycle in contrast with messages from repetitive orbit event cycles). Detection and reporting of data corruption shall be performed including those due to SEU.

A.4.4.9 **Instruments**

In case of detection by the CCS of an out of limit monitored parameter associated with one or more payload instruments, the CCS will put these instruments in a safe configuration, allowing further actions for the payload from the Ground.

It shall be possible to flexibly allocate this capability to the individual payload instruments. It shall be possible to modify, by software and data table update in the uplink from ground, the monitoring limits, including inhibit and enable, and the allocation of the monitoring speed, once the Satellite is in orbit.

A-4.4.10 **Mission Timeline Execution Support**

A.4.4.10.1 **Uplinking MTL Macro Command**

The Satellite shall permit pre-programming of nominal Platform and payload operations for up to 36 hours, by uplinking *from* ground a Master Timeline (MTL) of time-tagged high level macro commands, which as a sequence control the totality of the Platform/payload operations in orbit:

- Commands shall be at highest possible system level, but still permitting Satellite re-configuration flexibility for any feasible combinations of active payload instruments subsets, and any up- and downlink configurations as determined by the ground infrastructure and its availability constraints during the mission.

- Commands for re-configurations shall be structured such that essentially only variables have to be uplinked in a protocol format, whereas all permanent content of the commands, and their expansions into lower level command sequences and automatic procedures is stored and filled in on-board.

- Commands for the payload shall be transmitted by the Satellite to the proper payload instrument 10 seconds before the time tag, for expansion into detailed command sequences, and execution at the programmed timing, by and within the instrument itself.

- Suspension, update and resumption of non-executed MTL entries shall be possible from ground, by uplinking of individual entries or complete MTL sections or deletions. The Satellite shall at a suspension complete all MTL entries in process at that time.

- The "permanent" part of the MTL commands and their expansions into detailed sequences, which reside in the Satellite, shall be accessible to updating via uplink, as individual software modules or groups of modules, without interruption of nominal operations in orbit.

A.4.4.10.2 **MTL Execution Failures**

A fault or out-of-limit in the execution of an MTL entry shall not cause a change or discontinuation of the nominal MTL processing unless the Satellite failure detection and recovery system as specified suspends nominal operations; for example by activating the Payload Off Mode or the Safe Mode of the Satellite.

A.4.4.10.3 **Real Time Commands**

The Satellite shall interpret and act upon commands to payload instruments, both real-time and on the MTL, as necessary for its compliance with system monitoring and management requirements specified in this document.

A.4.5 DATA RANDLING REQUIREMENTS

A.4.5.1 Payload Data Handling Subsystem

The Payload Data Handling subsystem (PDHS) shall ensure instrument data acquisition, formatting, multiplexing, on-board storage, selective encryption and routing to the down link capabilities.

The PDHS shall provide:

- continuous data acquisition from all instruments, for the whole orbit without loss of data:
- acquisition of HK from the CCS, and Administration Messages;
- encapsulation of data from the NOAA instruments into CCSDS source packets;
- data formatting according to CCSDS recommendation using one common VCDU format for LRPT, HRPT, Global Data;
- scrambling and R-S encoding of VCDUs;
- capability of Global Data storage for the longest time period between successive Acquisition of Signal (AOS) at the METOP ground station(s) (see SOW Annex C);
- encryption of HRPT and LRPT data according to AD18;
- AVHRR data compression for the LRPT service;
- generation of fill CADU's for the HRPT and LRPT links;
- continuous broadcast service for HRPT and LRPT:
- Global Data dump service in X-Band;
- interface for synchronisation, telemetry, command, fault detection and recovery of the NOAA instruments;

A.4.5.2 Data Handlina Command and Control

The PDHS subsystem shall interface the Command and Control Subsystem (CCS). It shall allow the control, monitoring and synchronisation of the NOAA instruments and of the data recording, playback and telemetry sub-systems.

A.4.5.3 Data Handling of Measurement Data

A.4.5.3.1 Instruments Data Acquisition Requirements

Instruments shall format their data for multiplexing and recording in accordance with AD12. This may be performed by external means, in the case of the NOAA instruments.

The PDHS subsystem shall acquire data from each instrument and provide a formatting to the CCSDS standard (AD12).

Instrument Virtual Channel Data Unit Identifiers (VCDU-Id), the packetised data rate, and apportionment in Global Data, HRPT and LRPT are provided in SOW Annex C (AD4).

A-4.5.3.2 Data Formatting

Data acquired and buffered by the PDHS subsystem shall be formatted into transfer frames. These frames (VCDU), after encoding and Synchronisation insertion, become CADU's (Channel Data Access Unit), which are used for:

- HRPT and LRPT continuous broadcast service;
- storage and dump in X-Band.

The encoding will be 255, 223 R-S with an interleaving depth of four.

The structure of the Coded Virtual Channel Data Unit (CVCDU) shall be identical for the three streams and according the CCSDS standard. The length of each data field is reported below:

VCDU Primary Header: 6 bytes
VCDU Insert Zone: 2 bytes
VCDU Data Unit Zone: 984 bytes
CVCDU Trailer: 128 bytes

A.4.5.3.3 Data Storage of the Global Data Stream

The on board storage Sub-system shall be able to store the Global Data Stream for a time period corresponding to the longest interval between successive AOS at the METOP ground station(s).

It shall have a simultaneous and independent read and write capability.

It shall feed the X-band modulator with the required data rate.

A.4.5.3.4 Nodes of Operation

The PDHS subsystem shall have three main modes, Off, Standby and Operational Mode. For the Operational Mode the PDKS shall be able to simultaneously support the following main functions, and subsets of these functions:

- acquisition of data from the selected instruments
- data storage
- X-band data dump
- HRPT data broadcasting
- LRPT data broadcasting
- interface to the NOAA instruments via the NIU

A.4.5.3.5 Data Quality Requirement

The PDHS subsystem shall be able to acquire, format, record and distribute data to downlink facilities with the following quality:

- the probability of a bit error in a packet shall be less than 10^-9 (TBC).

- the probability of a packet loss (Ppl) due to errors in the header shall be less than 10^-6 (TBC).

- the probability of VCDU loss (Pvl) due to errors in the header shall be less than 10^-6 (TBC).

A.4.5.4 Pavload Data Links

A.4.5.4.1 Functional **Requirements**

The PDHS subsystem shall provide the following links for payload data distribution:

- Global Data Stream dump on X-Band.
- Direct Broadcasting L-Band to meteorological user ground stations (HRPT) (AD 17, 18).
- Direct broadcast on VHF-Band to meteorological user ground stations (LRPT) (AD 17).

A.4.5.4.2 Payload measurement and **Auxiliary** Data **Requirements**

The Global Data stream shall be recorded and dumped, at least (but not limited to) once per every orbit. For the design case a total duration of 10 minutes (TBC) per orbit, with an average number of dump operations per orbit of 1.2, shall be assumed on the X-Band link. (Thermal design for this subsystem shall permit a total duration of 20 minutes (TBC) per orbit).

The data of each complete orbit shall be dumped when the satellite elevation is greater than 5 deg.

Except for BER limitations the on-board acquisition, recording and downlink shall assure that all payload data are available for ground station acquisition.

A-4.5.4.3 Global Data (**X-Band**) Link **Requirements**

The PDHS subsystem shall ensure Global Data dump to ground stations with the required quality when the satellite elevation at the ground station is greater than 5 deg. Link attenuation due to atmospheric factors (i.e. rain, clouds, scintillation, etc.) not exceeded for 99.9% of time shall be taken into account.

Further link requirements are provided in Annex C of the sow (AD4).

A.4.5.4.4 **HRPT** Data Broadcasting Link **Requirements**

The PDHS subsystem shall ensure continuous HRPT data broadcasting to meteorological ground stations. The EIRP shall be such to enable any ground station defined in Annex C of the SOW (AD4), whose G/T is 6.5 dB/K, to receive data with the required quality when the satellite elevation is greater than 5 deg. Link attenuation due to atmospheric and ionospheric factors not exceeded for 99.8% of time shall be taken into account.

Other ionospheric effects on the downlink channel, i.e. group and time delay, dispersion and ionospheric scintillation, shall also be taken into account in the link budget.

Encryption of the data is required (AD 18).

Further link requirements are provided in Annex C of the SOW (AD4) as well as AD 17.

A.4.5.4.5 LRPT Data Broadcasting

The PDHS subsystem shall ensure continuous LRPT data broadcasting to meteorological ground stations defined in Annex C of the SOW (AD4). The EIRP shall be such to enable data reception with the required quality to:

- ground stations, whose G/T is -22.4 dB/K, when the satellite elevation is greater than 5 deg.
- ground stations, whose G/T is -30.4 dB/K, when the satellite elevation is greater than 13 deg.

Link attenuation due to ionospheric factors not exceeded for 99.82 of time shall be taken into account. Other ionospheric effect on the downlink channel, i.e. group and time delay, dispersion and ionospheric scintillation, shall also be considered in the link budget.

Link attenuation due to atmospheric factors can be considered negligible.

Further link requirements are provided in Annex C of the SOW (AD4) as well as AD 17.

A.4.6 TIME MANAGEMENT REQUIREMENTS

A.4.6.1 CCS Time and Frequency Signals

The Platform CCS shall provide a time signal and a frequency reference signal (clock) to all METOP instruments, for time-tagging of data, and for synchronising local clocks respectively.

The METOP central clock shall have a stability better than 10^-10 short-term (one second), and a long term drift of less than 10^-9 (100 minutes).

METOP shall enable the correlation of the METOP clock to UTC, by ground stations, with an inaccuracy with respect to UTC introduced by the METOP on-board systems into the correlation measurement, of less than 100 microseconds. The inaccuracy of the METOP on-board systems with respect to UTC shall also cover the sync differentials between the Platform clock and payload instrument interfaces.

The CCS shall use the CCSDS time code standard AD7 (TBC).

A.4.6.2 Synchronisation of Instrument Clocke

Instruments shall maintain an internal clock which shall be synchronized with the satellite time. The clock shall also be used for command block execution scheduling as well as for housekeeping and measurements data datation.
It shall be possible to synchronise the clocks of each instrument to the CCS master clock individually, without influencing other users connected to the CCS bus.
It shall be possible to verify, at any time during nominal operations, the synchronisation between the Instrument clock and the CCS master clock.

A.4.6.3 Correlation of Measurements to CCS Time

A.4.6.3.1 Ancillary Data Time Tagging Accuracy

All time-tagging of any ancillary data required to be delivered to the Payload from the Platform shall be with an accuracy of better than three times the resolution of the time code of the METOP master clock, with respect to the time of occurrence of the event.

A.4.6.3.2 Housekeeping Data Datation Accuracy

Housekeeping data shall be time tagged with an accuracy of 4 msec.

A-4.6.3.3 Science Data Datation Accuracy

Datation of instrument data with respect to the CCS master time shall be sufficient to allow the instrument specific performance requirements to be met, and in all cases with a maximum inaccuracy of 4 msec.

A.4.6.4 Correlation of CCS Time to UTC

Correlation between the CCS on-board time to UTC shall be performed in the TT&C ground station, by correlation of the leading edge of the first bit of the sync word of the S-band telemetry frame to UTC. The inaccuracy of this leading edge as transmitted, to the CCS clock, is to be considered as-part of the on-board contribution to the correlation measurement specified in Section A.4.6.1.

A.4.6.5 Macrocommand Execution

Time-tagged macrocommands shall have a time-tag resolution of 4 msec, and shall start the expansion with an accuracy of 20 msec.

For each macrocommand there shall be an "event of interest" which shall normally correspond to the start of generation of dated measurement data. Macrocommands shall have a maximum execution duration, up to the event of interest, which is deterministic within 50 msec accuracy.

A.4.7 LAUNCHER INTERFACE REQUIREMENTS

The satellite shall be compatible with launch on both Ariane 4 and Ariane 5. The selection of the launch vehicle will be made at the start of Phase C/D.

The Ariane 4 version to be used will be the smallest consistent with the satellite launch mass, inclusive adaptor, for injection in the orbit specified in Section A.4.3.1.1. The Ariane 4 fairing envelope used for dimensioning the satellite will be the type 02 specified in AD5 para 4.3.4.

For the purposes of the Phase B a single launch case shall be taken.

Interface requirements on the satellite from the launcher are defined in AD5 and AD6.

The launcher performance, injection accuracy and kinematic conditions at separation are defined in ADS and AD6.

The launcher induced environment, dynamics, acoustics, thermal, EMI and cleanliness are defined in AD5 and AD6.

Where requirements differ from Ariane 4 to Ariane 5, the worst case shall be taken as the dimensioning requirement.

A.4.8 NATURAL AND INDUCED ENVIRONEMENTAL REQUIREMENTS

A.4.0.1 General

The METOP Satellite will experience natural and induced environments throughout its lifetime: from manufacturing to launch site, launch, on-orbit operation and disposal. The environments specified in this document shall be combined as appropriate for METOP Satellite design and verification purposes, based on credible occurrences.

In the following, reference to both the Ariane 4 and the Ariane 5 induced environments is provided. For design purposes and in order to guarantee the METOP compatibility with both launchers, the most demanding combination of the two induced environments applies to the METOP Satellite design.

A.4.8.2 Terrestrial Environment

A-4.8.2.1 General

The METOP Satellite and its GSE shall be protected from, or designed to survive without performance degradation the applicable ambient natural environment during commercial air, sea and road transportation and handling in Europe and at the Kourou (CSG) launch site.

A.4.8.2.2 Flight Hardware Protection

Where it is not feasible or cost-effective to design the flight hardware to withstand the terrestrial environment directly, the flight hardware shall be protected by suitable GSE and maintained within the environmental envelope specified for launch and on-orbit operations.

A.4.0.2.3 Mechanical Environment

The static and dynamic mechanical environment affecting the METOP Satellite during all ground operations shall be maintained within the envelope of the defined launch mechanical environment (i.e. ground activities not driving the design).

A-4.0.2.4 Contamination and Cleanliness Environment

A.4.8.2.4.1 AIT Activities

The METOP satellite and its GSE shall be designed such to allow the performance of all ground Assembly, Integration and Test (AIT) activities, both in Europe and at the Launch Site, in a controlled area with a minimum cleanliness level of 100000, as defined in AD3.

A.4.0.2.4.2 Launch Activities

During the launch preparation and ascent phases, the METOP satellite will be subjected to a contamination and cleanliness environment as defined in AD5 and AD6.

A.4.8.3 Neutral Atmosphere

A.4.8.3.1 A-spheric Density

The Neutral Atmosphere conditions applicable to the METOP Satellite are specified in AD20.

A.4.0.3.1.1 Model Representation

The Neutral Atmosphere continuous representation is given for the altitude range from 90 to 2500 km by the Marshall Engineering Thermosphere (MET) model, RD14, derived from the so-called JACCHIA model. The model computes the atmospheric density for any orbital location for any time within the mean solar cycle from August 1997 to August 2000, based on predictions of the 13 months smoothed values of the 10.7 centimetre solar radio noise flux (F10.7) and geomagnetic activity index (Ap). The solar cycle shall be considered to be repetitive after August 2000.

A.4.0.3.1.2 Atmospheric Density Parameters

The atmospheric density parameters defined in Section A.4.3.2.6 shall be used for the design of the METOP attitude control functions.

A.4.0.3.1.3 Parameters for Propellant Budgeting

The atmospheric density parameters derived for the applicable mission period from Section A.4.0.3.1.1 shall be used for propellant budgeting.

A.4.0.3.2 **Thermospheric** Winds

The range and variation of thermospheric winds covering Equinox/Solstice, shall be taken into account for METOP Satellite drag calculations. For design analyses wind speeds of up to 900 m/s along the 12 hr LST meridian, anti-sun direction, across the polar caps for up to 30 minutes around the orbit shall be assumed.

A.4.0.4 Plasma

The Ionospheric Plasma environment as defined in AD20 applies to the METOP Satellite. For the electron density, temperature and ionic composition of the ionosphere, refer to AD21.

A.4.8.5 Charged Particle Radiation

Charged particle radiation affects materials, chemical processes, electronic components and the propagation of light through optical materials.

Two groups of charged particles are identified: magnetospheric particles and cosmic rays.

A-4.0.5.1 **Magnetospheric Particles**

These particles are known as the trapped radiation phenomenon (Van Allen radiation). The general shape of the Van Allen belts follows the shape of the geomagnetic field and therefore the METOP Satellite will penetrate most deeply into the belts in the region of the South Atlantic Anomaly.

A.4.8.5.1.1 Particle Characteristics

AD20 specifies the numerical data on energy levels, particle flux densities, variations with altitude, inclination, time, etc. Reference is made therein to radiation models AP8 and AE8 for protons and electrons respectively to be used for the METOP environment determination.

A.4.8.5.1.2 Polar Orbit Effects

Transient fluxes in polar orbits associated with the aurora1 zone shall be taken into account for the METOP Satellite design.

A.4.8.5.2 Cosmic Ray8

Cosmic rays are either galactic or solar. AD20 provides the available environmental data, synthesised into empirical models, with variations in solar activity an time. A model to represent the cosmic rays deflection due to the earth's magnetic field and experienced in polar orbits is also therein provided.

A.4.8.6 Electromagnetic Radiation

AD20 specifies the electromagnetic noise environment due to galactic, solar, near earth natural plasma and man-made radio sources.

A.4.0.7 Meteoroids/Space Debris

AD20 specifies the models to be used for defining the meteoroid and space debris environment applicable to the METOP satellite.

A.4.8.8 Magnetic Fields

The earth's magnetic field deflects charged particles and reflects low energy cosmic rays for altitudes lower than 2000 Km. It varies considerably with the time on a 5 to 10 year cycle. AD20 specifies the applicable magnetic field environment.

A.4.8.9 Physical Constants

AD20 specifies the sun-earth constants, the pressure parameters and the thermal environment to be used for the METOP satellite design.

A.4.8.10 Gravitational Field

The coefficients J1, J2, J3, J4 and J2^2 of the gravity model GEM-T1 (see AD22) shall be used for the METOP Satellite. The reference ellipsoid WGS84 (see AD23) shall be used for calculations of position, altitude and attitude.

A.4.8.11 **Atomic Oxygen Environment**

The level of atomic oxygen environment to be taken as design and material selection parameter for the METOP Satellite shall be 3.2x10^16AO/m^2/s as flux on a ram surface for solar maximum conditions.

A.4.8.12 EMC Environment

The METOP Satellite shall be designed to be compatible and to operate, in addition to the already defined natural magnetic environment, also in the induced EMC environments generated by:

- ground facilities
- launch vehicle
- payload and service instruments

See also the EMC/RFC requirements in Section A.4.9.7.

A.4.8.12.1 **Launcher Radio and EMC Environment**

The environmental characteristics and the limits in terms of radiated levels (spurious or intentional) from the launcher that will be encountered by the METOP Satellite are specified in AD5 and AD6.

A.4.0.13 **Thermal Environments**

The METOP Satellite shall be compatible with all encountered natural and induced thermal environments during launch, ascent, transfer and orbital operations, including:

- thermal radiation originated or re-emitted from payload instruments;
- incident fluxes originated or reflected from the launch vehicle, Sun, Earth, the METOP Satellite itself;
- the dissipated electrical power from all METOP electrical boxes.

A.4.8.13.1 Launch Preparation and Ascent

During all launch preparation activities at the launch site and the ascent phase until jettison of the nose-fairing, the METOP Satellite shall be compatible with the air conditioning characteristics and the thermal fluxes as defined in AD5 and AD6. Aerothennal fluxes as specified in AD5 and AD6 shall be taken into account for the ascent phase after fairing jettison.

A.4.0.14 **Mechanical Environments**

A.4.0.14.1 Launch Environment

During the Launch phase, the METOP Satellite is subjected to a launcher induced mechanical environment consisting of static and dynamic loads.

particles and cosmic rays.

A.4.8.5.1 **Magnetospheric** Particles

These particles are known as the trapped radiation phenomenon (Van Allen radiation). The general shape of the van Allen belts follows the shape of the geomagnetic field and therefore the METOP Satellite will penetrate most deeply into the belts in the region of the South Atlantic Anomaly.

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A.4.0.13.1 Launch Preparation and Ascent

During all launch preparation activities at the launch site and the ascent phase until jettison of the nose-fairing, the METOP Satellite shall be compatible with the air conditioning characteristics and the thermal fluxes as defined in ADS and AD6. Aerothennal fluxes as specified in AD5 and AD6 shall be taken into account for the ascent phase after fairing jettison.

A.4.0.14 **Mechanical Environments**

A.4.8.14.1 Launch Environment

During the Launch phase, the METOP Satellite is subjected to a launcher induced mechanical environment consisting of static and dynamic loads.

A.4.8.14.1.1 Satellite Steadv State Acceleration

The highest static accelerations occurring to the METOP Satellite during launch are defined in AD5 andAD6.

A.4.8.14.1.2 Satellite Low Frequencv Vibration Levels

The sinusoidal vibration levels to be encountered by the METOP Satellite during launch at the launcher to spacecraft interface plane are specified in AD5 and AD6.

A.4.8.14.1.3 Satellite Shocks induced bv the Launch Vehicle

The shock spectrum induced by the Launch Vehicle to the METOP Satellite at the bolted interface shall be derived from AD5 and AD6, depending on the Interface adaptor selection.

A.4.8.14.1.4 Satellite Acoustic Vibration

The ambient induced noise encountered under the launcher nose-fairing will not exceed the levels defined by octave bands in AD5 and AD6.

A.4.8.14.1.5 Satellite Random Vibrations

The random vibrations environment transmitted by the launcher to the METOP satellite via the launch vehicle structure is specified in AD5 and AD6.

A.4.8.14.1.6 Equipment Ouasi-Static Desisn Load Factors

The contractor shall derive all lower level structural sizing requirements at equipment level based on the requested minimum box resonant frequency and considering the environmental requirements imposed at Satellite level.

For preliminary design purposes of new equipment, the use of the quasi-static design load factors below is recommended as a starting point, before the actual load factors are derived.

- For equipment with mass greater or equal to 100 kg: 15 g
- For equipment less than 100 kg, the design load factor shall be taken from the following table, which shall be interpreted as a curve in which the values provided shall be linearly connected on a logarithmic scale.

Equipment Mass (kg)	**Design Load Factor (g)**
1	65
3	55
5	50
10	43
30	30
100	15

These quasi-static design load factors have to be applied, for dimensioning

- at the equipment CoG;
- into the worst spatial direction with respect to the resulting reactions/stresses (to be understood as a sum vector);
- the loads not acting simultaneously.

A.4.8.14.1.7 Equipment Low-Frequency Vibration Levels

Each equipment shall be designed to withstand, in each of the three orthogonal reference axes, the low frequency vibration levels specified in the following Table:

Frequency (Hz)	**Acceleration (g peak)**
6 - 20	Acceleration to be derived from the curve obtained by linear connection, on a logarithmic chart, of the accelerations at the two extremes of the range, i.e. 1.0g at 6Hz and 15.0g at 20Hz.
20 - 60	15g
60 - 100	6g in case of large flexible items
	15g for all items packaged in a box-type structure

A.4.8.14.1.8 Equipment Shock Environment

Each equipment shall be designed to survive, without permanent degradation of performance requirements, the exposure to the shock environment defined in the following Table, where the acceleration is to be derived from the curve obtained by linear connection, on a logarithmic chart, of the provided points:

Frequency (Hz)	Shock Acceleration (g)
100	37
900	350 (Q > 10) 310 (Q = 10)
2000	350 (Q > 10) 310 (Q + 10)
4000	300

The shock spectrum in each direction of the three orthogonal axes shall be equivalent to a half sine pulse of 0.5 msec duration and 200 g amplitude (zero to peak).

A.4.0.14.1.9 <u>Equipment Random Vibrations</u>

The contractor'shall establish the random vibration environment for each METOP equipment based on the overall satellite random and acoustic environments. In the early stage of the design and before derivation of the METOP specific Equipment Random Spectra, the environment specified in the following table shall be applied.

Axis of Appli- cation	Frequency Range (Hz) Vertical axis, out of plane	Frequency Rang. (Hz) Lateral axis, in-plane	Levels
All three axes	20 - 100	20 - 100	
	100 - 400	100 - 400	0.29 g^2/Hz for M ≤ 5kg
			0.07x(M+20)/(M+1)/g^2/Hz for M > 5kg and M < 65.5kg
			0.09 g^2/Hz for M ≥ 65.5kg
	400 - 2000		-3 dB/Octave
		400 - 2000	-4 dB/Octave

A.4.8.14.1.10 <u>Pressure During Launch</u>

The METOP Satellite shall be designed to withstand the static pressure evolution encountered during the launch ascent phase as specified in AD5 and AD6.

A.4.8.14.2 On-Orbit Induced Environment

The METOP Satellite shall accommodate the induced environment consequent to reactive forces, torques, moments vibrations and shocks from payload appendages deployments and payload operation.

A.4.9 ELECTRICAL DESIGN REQUIREMENTS

A.4.9.1 Digital Electronics and Data Processing

A-4.9.1.1 Software Growth

METOP computers shall permit software growth in accordance with ESA-PSS-05-O (AD29).

A-4.9.1.2 Computer Memory Protection

METOP computers shall have protection against the effects of SEU.

A.4.9.1.3 Memory Random Access

All METOP memories shall support random access.

A.4.9.1.4 Direct Software Loading

Direct software loading from EGSE into MEMP on-board memories shall be possible for test and check-out purposes.

A.4.9.1.5 Use of ASICs

The use of ASICs to perform functions which could otherwise be performed by software is discouraged. Every case where the Contractor proposes to use an ASIC to perform tasks which could be performed by software shall be agreed with the Agency.

A.4.9.2 Electrical Power and Energy

A.4.9.2.1 Total Power/Energy

The METOP Satellite shall provide the total electrical power/energy resources, including margins, requested to satisfy the Satellite functions and to accommodate the Payload instruments identified in this document during the nominal satellite lifetime in all modes.

A.4.9.2.2 Power Availability

The METOP Satellite shall be designed to provide the requested power levels for the life required in Section A.3.5 and for the given orbit conditions for any launch date of the year, starting from 1 Jan 2000 to 1 Jan 2010, and considering the worst case conditions (End-of-Life degradation factors, pointing accuracy, etc.).

A.4.9.2.3 Power Level Management

The METOP Satellite shall be designed to maintain the specified power levels obtained by any realistic combination of electrical loads, including high/low consumption peaks and short-term transients during switching at the entry/exit from eclipse.

A.4.9.2.4 Power Generation Transitions

Mode transition from battery generated power (eclipse) to solar array generated power (sunlight) and viceversa, including power peaks condition (batteries in support of the solar arrays), shall be fully automatic.

A.4.9.2.5 Power during Pro-Launch and Launch

The power consumption requested by the METOP Satellite during the launch preparation and the ascent phases shall be compatible with the maximum dissipated power acceptable to the launcher, as specified in AD5 and AD6.

A.4.9.2.6 Battery Management

The battery management shall:

- be fully automatic and require ground intervention only for optimisation of battery control parameters;
- provide good protection of the batteries (e.g. against over-temperature, battery cell short circuit, over-charging and over-discharging), in view of the high number of duty cycles expected during the nominal orbit life;
- minimize the temperature differences among batteries and among cells in the same battery;
- be such that failures and degradations can be overcome at the level of individual batteries;
- provide monitoring of the overall battery status (e.g. voltage, current, temperature) together with the status of defined groups of cells inside each battery with the purpose of monitoring battery health conditions and promptly detect the need for battery switch-off.

A.4.9.2.7 Power/Energy Budget

Long term peaks (peaks averaged over 1 minute TBC) as well as the average power figure shall be taken into account for power / energy budgeting purpose and shall ensure a positive energy margin for each orbit.

A-4.9.2.8 Battery Energy Budget

The battery energy budget shall demonstrate for each orbit a positive margin of 10% for both sunlight and eclipse when considering the nominal power profile, including the satellite power peaks, at the End of Life, excluding modelling inaccuracies.

A-4.9.2.9 Battery Depth of Discharge

The battery depth of discharge shall be specified by the Contractor in line with the METOP Satellite lifetime and mission requirements.

During the Launch mode in the LBOP the DOD shall not exceed 602.

A.4.9.3 Electrical Distribution

A.4.9.3.1 Power Distribution

The MRTOP Satellite shall distribute the requested power (survival, average and peaks) to subsystems and payload instruments during the nominal satellite lifetime as required by the specified operational scenarios.

A.4.9.3.2 User Power Interface

The MRTOP Satellite power system shall generate and distribute DC power with a voltage between 37 and 22 V at the User equipment interfaces (i.e. including power losses and degradations).

A.4.9.3.3 Survival Power

Survival power shall be distributed to any equipment requiring it during launch, safe mode, stand-by mode and any other mode where the equipments are OFF.

A-4.9.3.4 Power Line Parameters

The hardware design shall permit adaptation of power line parameters (e.g. measurements, protections) at a late stage of the programme, latest before starting of flight model manufacturing.

A.4.9.3.5 Power System Protection

The MRTOP Satellite shall have protections for protecting the power source from overloads or faults in the distribution system and in any load, including payloads. The protections shall, as far as practical, be ground commandable redundant and/or resettable.

The METOP Satellite electrical distribution design shall avoid propagation of any electrical failure to other power users and shall be free of single point failures.

A-4.9.3.6 Power Switching

The METOP Satellite shall permit switching of power sources to redundant paths, and of power to all payload instruments individually, either by use of internal switches or, where not practical, by use of dedicated external switches.

A.4.9.3.7 Power Distribution Monitoring

The MRTOP Satellite power system shall include the capability to monitor, evaluate and control the power status from the source to the load interface by:

- allowing current and voltage measurement of each load to enable power consumption determination;
- monitoring and controlling the switching configuration of loads with power on;
- monitoring and controlling the switching configuration of loads with power off.

A.4.9.4 <u>Cable Harness, Wiring and Routing Requirements</u>

A.4.9.4.1 Redundant Functions

Harness wires and connector pins carrying redundant functions shall be physically separated and isolated from each other.

A.4.9.4.2 Protection against Overcurrent

All wiring shall be protected against overcurrent consistent with the conductor rating and applicable derating factors (as specified in AD14).

A-4.9.4.3 Cable Harness Bundles

Cable harness bundles shall be designed in accordance with categories defined EMC sensitivity (as specified in AD33).

A-4.9.4.4 Wiring Installation

Wiring installation requirements shall be derived from a selected MIL-STD or equivalent design standard.

A.4.9.4.5 Harness Labelling

Harness shall be marked and labelled in accordance with AD25 or equivalent design standard.

A.4.9.4.6 Cable Shielding

Cable shielding shall comply with the following:

- shields shall not be used as intentional return paths except in case of coax. cables, in which case the appropriate grounding scheme has to be implemented;
- where the cable shield is utilized principally to reduce interference level, the shield shall be grounded at both ends and at intermediate points along its length unless alternative grounding methods are specifically agreed;
- the overall harness shield shall be grounded at both ends and also at intermediate points approx. every 25 cm along its length;
- when double or triple shielding is used, each shield shall be grounded separately.

A.4.9.4.7 Connector Definition and Protection

Connectors shall be located, or physically protected, such that they can not accidentally be damaged or wrongly connected during the ground activities. All connectors shall be fixed to the relevant unit, bracket or other fixed mount.

Connector types, configurations (e.g. number of pins) and location shall be selected to preclude damage or inadvertent operation resulting from mis-mating.

A.4.9.5 **High Voltage Design Requirements**

A.4.9.5.1 **High Voltage** Part8

The presence of high voltage parts shall be taken into account and proper discharge tests shall be performed at unit/system level to prove the hardening of the neighbour units and system against their H.V. breakdown.

A.4.9.5.2 **Multipaction**

All METOP Satellite high power microwave equipment shall be designed and tested such that a 6 dB margin between the maximum expected power levels and the onset of multipaction is established.

A.4.9.5.3 **Corona Discharge**

All METOP Satellite high voltage equipment shall be designed and tested to free from corona discharge effects, in the on-ground, launch and in-orbit environment anticipated.

A.4.9.5.4 **Arcs**

High voltage equipment shall be designed to withstand the effects of arcs. The susceptibility of H.V. equipment to arcing shall be characterised.

A.4.9.6 Mechanism Electrical Requirements

A.4.9.6.1 **Electrical Design**

Mechanisms hall be designed to meet all the pertinent requirements regarding electrical interfaces and performances, and shall exhibit stable electrical characteristics and electro-mechanical transfer functions throughout their specified period of life. Electrical power consumption, generated electrical disturbances and propensity to fault propagation shall be minimised by design.

A-4.9.6.2 **Insulation**

Wires shall be insulated from the structure and from each other by not less than 1MΩ with 500 VDC applied for 5 minutes.

Motor windings shall be insulted from the structure and from each other by not less than 100 MΩ with 500 VDC applied for 5 minutes.

A.4.9.6.3 Grounding

Each mechanism shall be electrically bonded to the satellite structure by means of a bonding strap allowing to achieve a DC resistance, measured between the mechanism and the ground plane in both directions of polarisation, of less than 10 mΩ.

A.4.9.6.4 **Overcurrent** *Protection*

Mechanisms containing electrical parts and circuitry shall incorporate adequate means of protection against excessive currents due to abnormal applied voltages or internal conditions (e.g. faults). The current protection can be provided externally.

A-4.9.6.5 **Torsion of Wires**

Torsional loads shall not be applied to wires which change their configuration, e.g. wires around a hinge.

A-4.9.7 **EMC/RFC**

A.4.9.7.1 Operation in EMI Environment

The METOP satellite shall be designed to operate in the EM1 environment, which it will experience through all operational phases, during its design life.

Active emitters on board the satellite shall not perturb the passive radiometer instruments in the payload by more than 202 of their sensitivity over any part of their spectral range.

A.4.9.7.2 **EMC and Power Quality Design**

The METOP Satellite shall be designed considering AD33 as a starting point for the derivation of METOP satellite specific EMC requirements.

A.4.9.7.3 **System EMC Safety Margin**

An overall safety margin at system level shall be proved by test with respect to the external and the self-generated conducted and radiated environment.

The EMC safety margin of the MRTOP satellite shall be at least:

- 20 dB where potential hazardous situations are identified (safety critical circuits)
- 6 dB in all other cases.

Where more stringent safety margins are dictated by the Launcher, by relevant local National Regulations or by specific equipment supplier, then these shall apply.

A.4.9.7.4 **Power Grounding**

The METOP satellite shall have a Distributed Single Power Ground (DSPG). Ground reference points shall be accessible during ground activities. Structure shall not be used as an intentional current return of primary and/or secondary power.

A.4.9.7.5 **Conductivity of External Surface**

All METOP external metallic surfaces shall be grounded.

A-4.9.7.6 **Instrument Grounding Provisions**

The METOP Satellite shall have provisions for accommodation of Payload Instruments designed for a Star Power Grounding system (NOAA instruments).

A.4.9.7.7 Structure Isolation

The isolation between the single ground reference point and the structure, before connection to structure but with all current return lines connected and all hardware installed and connected, shall be such that the Satellite and equipment common mode impedance is conunensurate with the EMI environment.

A.4.9.7.8 Structural Parts Bonding

All metallic members of the structures shall be designed to be electrically bonded by direct metal-to-metal contact (preferred method) or bonding straps without exceeding 2.5 mΩ DC contact resistance measured with both directions of polarization.

A.4.9.7.9 CFRP Bonding Resistance

All CFRP members of the structure shall be designed for a bonding resistance of less than 1 kΩ DC from any point of the surface to the metallic structure.

A.4.9.7.10 CFRP Path

It is not permitted to use the CFRP structural members as bonding path.

A.4.9.7.11 Equipment Power Isolation

Any primary power and return input lead of an equipment shall have a DC isolation of at least 1 MΩ shunted by not more than 50 nF to equipment chassis and between power input lead and secondary power leads.

A.4.9.7.12 Equipment Bonding

Electrical equipment shall have a bonding resistance equal to or less than 2.5 mΩ DC per bonding junction between:

- different parts of the equipment chassis;
- connector receptacles and equipment chassis/connector brackets;
- equipment chassis and bond strap;
- bond strap and structure;

A.4.9.7.13 Equipment Connection to Structure

Bonding connections shall be designed for 10 mΩ DC or less between equipment surface and METOP Satellite structural interface.

A.4.9.7.14 Bonding Sizing

The bonding straps shall be sized to safely carry any expected inadvertent fault current (150% of circuit protection device rating). The length to width ratio shall not exceed 5 to 1.

A.4.9.7.15 Equipment Shielding

Each equipment shall be enclosed in an electrically conductive and non-magnetic case which shall form an all-enclosing shield for electromagnetic fields generated by the equipment.

A.4.9.7.16 Mechanical Equipment Grounding

Mechanical equipment which do not perform any electrical function shall be grounded to the spacecraft ground point by a bonding resistance not greater than 1 kΩ DC.

A.4.9.7.17 Thermal Blanket Grounding

Each Thermal Insulation blanket shall be connected to the structure with a resistance of less than 100 mΩ DC.

A.4.9.7.18 Thermal Blanket Reference Points

Each layer of Thermal Insulation Blanket shall be connected to the structure with at least two reference points.

A.4.9.7.19 Metallised Foil

Each metallised foil shall be electrically connected to the reference point of the Multi Layer Insulation.

A.4.9.7.20 Thermal Blanket Surface Resistance

The DC resistance between the MLI reference point and any point belonging to a metallised face of any foil shall be less than 50 Ω.

A.4.9.7.21 Satellite Grounding Provisions

If the satellite design does not provide a continuous metallic structure which can be utilised for equipment grounding, the satellite shall have grounding provisions for:

- safety-grounding of metallic chassis and shields of equipment containing hazardous voltage systems, during ground operations with access to the grounding provision so that it can be connected with the facility safety ground;

- equipment grounding of equipment secondary power systems, harness shielding etc. This grounding provision shall have low impedance consistent with Section A.4.9.7.13.

A.4.9.7.22 Satellite Generated Emissions

With respect to satellite generated spurious electromagnetic emissions, both radiated and conducted on power and signal lines, the satellite shall comply with AD33.

A-4.9.7.23 Instrument Generated Emissions

Further specific constraints on satellite generated radiated and conducted emissions for compatibility with the Payload experiment, **shall** be identified by the Contractor as specific **METOP** satellite EMC requirements.

A-4.9.7.14 **Launcher Generated Emissions**

The **METOP** Satellite shall be designed to be compatible with the launcher radio and electromagnetic environment as specified in AD5 and AD6.

A.4.9.7.25 **Passive Intermodulation**

The METGP satellite **design** shall prevent the occurrence of Passive Inter Modulation Products **(PIMPs)** between **RF** transmitters which could have a detrimental effect.

A.4.9.7.16 **EMC Analysis**

Upon ESA approval, EMC analysis tools can be used to assess the **EMC** design of the **METOP** Satellite. In this case, an extra margin of at least 6 **dB** shall be taken into account to cover model uncertainties.

A.4.10 MECHANICAL DESIGN REQUIREMENTS

A.4.10.1 Mechanical Design

A.4.10.1.1 Strength

The primary and secondary structures and equipment of the **METOP** Satellite and its GSE shall be of adequate strength to withstand, without detrimental deformation at limit load, without yielding at yield load and without failing at ultimate load, all credible combinations of loads and associated environments encountered during Ground and Flight activities including assembly, transport, launch and orbital operations.

The following sources **shall** be referred to **for** design strength and other physical properties for use in the design of the flight hardware:

- **MIL-HDBK-5D** for metals **(RD21)**;
- MIL-RDBK-17A for laminates and bonded structures **(RD22)**;
- other sources approved by ESA.

For all applications, material **"A"** allowable values shall be used except for stiffnees where mean values shall be used. Refer to the definition of **"A"** allowable values in **RD20**.

A.4.10.1.2 **Safe-Life/Fail-Safe Design**

All load carrying hardware of the METGP Satellite shall be designed for damage tolerance and meet safe-life requirements as the preferred design criteria or fail-safe requirements **utilising** mechanical redundancies.

A-4.10.1.3 **Attachment Hardware**

The attachment hardware **(such** as bolted or riveted joints) shall be designed to be fail-safe.

A.4.10.1.4 **Fracture Control**

The METOP structures and pressurised systems shall be designed and verified according to the fracture control requirements of to the extent identified in Annex B of the SOW, with the following qualifications:

A.4.10.1.4.1 <u>Identification of PFCI's</u>

The identification of Potential Fracture Critical Items (PFCI's) shall be limited to the following items:

- Pressurised Systems
- Rotating machinery
- Fasteners in safe-life application
- Items fabricated using welding, forging or casting, and used at limit stress levels exceeding 252 of the ultimate tensile strength
- Non-metallic structural items

A.4.10.1.4.2 <u>Pressurised Systems</u>

All pressurised lines and fittings shall be proof tested to at least 1.5 x Maximum Design Pressure (MDP).

A.4.10.1.4.3 <u>Rotating Machinery</u>

Rotating machinery (reaction wheels and gyros) shall be proof spin tested to at least 1.1 x nominal operational speed.

A.4.10.1.4.4 <u>Fasteners</u>

Fasteners shall be classified and analysed as any other structural item. Fasteners smaller than M5 shall not be used in safe-life application. For fasteners equal to or larger than MS, the following requirements apply:

- Titanium alloy fasteners shall not be used in safe-life application.

- All Potential Fracture Critical Fasteners shall be procured and tested according to aerospace standards or specifications with equivalent requirements.

- All safe-life fasteners shall be marked and stored separately following NDI or proof testing.

A.4.10.1.4.5 <u>Welding, Forging or Casting</u>

For each of the items identified as PFCI, a crack growth (safe-life) analysis shall be performed, demonstrating that no failure will occur within 4 times the complete service life.

A.4.10.1.4.6 Non-metallic Structural Items

Non-metallic structural items shall be proof tested to at least 1.2 x limit load.

A.4.10.1.5 Impact **Damage Tolerance**

METOP equipment boxes shall be designed for "bench shock" loads, and the integrated METOP assemblies shall be protected (e.g. by guard rails in the GSE) from impact loads by ground operations personnel and transport modes.

A-4.10.1.6 **Qualification/Design** Loads

For design and qualification purposes, a qualification factor of 1.25 shall be applied to all flight limit loads.

A.4.10.1.7 **Margins** of Safety

All structural/mechanical items shall have positive margins of safety for all load conditions, using the applicable safety factors specified in the following table, on top of the qualification/design loads:

Components/Load Cases	**Minimum Factors of Safety**		
	Proof [a]	**Yield**	**Ultimate**
Non Pressure Load Cases [b] [c]:			
• General Structure, Metallic	-	1.1	1.5
• Non-Metallic Structures	1.2	-	1.5
• Mechanisms and Mechanism Components	-	1.4	2.0
For Pressure Loads [c]:			
• Pressure Vessels	1.25	-	1.5
• Pressurised Components:			
- Lines and Fittings:			
> less than 38mm diameter	2.0	-	4.0
> 38mm diameter of greater	1.5	-	2.5
- Valves, regulators etc.	1.5	-	2.5
• Sealed boxes	1.5	-	2.5
• Potentially explosive containers	1.5	-	2.5

a. No yielding is permitted at proof load or pressure. Protoflight hardware shall not yield at any testing. An uncertainty factor of 1.25 shall be appplied to flights limit loads derived from the launcher/satellit preliminary coupled dynamic analysis.

b. If structures are verified bv analysis only, then I.25 for yield (metallic structures) and 2.0 for ultimate conditions (metallic and non-metallic structures) and 2.0 for ultimate conditions (metallic and non-metallic structures) shall apply. Use of this option requires prior approval by ESA.

c. 1) For combined load, where L(P) is the load due to maximum operating differential pressure and L(M) is the non-pressure limit load, the factored load case (ultimate) shall be: 1.5 L(M) + 1.5 L(P).

2) For load cases involving thermal loads, the thermal stress at the applicable temperature shall be factored by 1.5 to determine an equivalent ultimate thermal load, and this shall be added to 1.5 times the non-pressure load and/or pressure load.

3) Where pressure and/or temperature relieve the mechanical load, a Factor of Safety of 1.0 shall be used for L(T) and L(P). In this case, L(P) shall be based on minimum operating pressure.

A.4.10.1.8 Static/Dynamic Characteristics

The METOP Satellite configuration shall be designed such that under limit load conditions, at the applicable worst case environments, the "as designed" static envelope (including the root mean square manufacturing tolerances) will not exceed the allowable dynamic envelope during ground, transport, launch and on-orbit phases.

A.4.10.1.9 On-Orbit Loads Attenuation

The METOP Satellite structures shall be designed to attenuate as much as possible the transmission through the mounting interface of each equipment of any dynamic load and vibration generated on-orbit in the Satellite by other instruments.

A.4.10.1.10 Dynamic Coupling

The mechanical items shall be designed as far as possible such that they meet a minimum eigenfrequency of 100 Hz (TBC), plus margins in case of analytical prediction, to eliminate dynamic coupling or to withstand dynamic factors induced by coupling, whatever is more mass/cost effective. This applies both during launch and on-orbit operations.

A.4.10.1.11 Launcher Frequency Requirement

In order to avoid dynamic coupling between the low-frequency of the launcher and the METOP Satellite modes, the satellite shall be designed with a structural stiffness which ensures the frequency requirements specified in ADS and AD6.

A.4.10.1.12 Equipment Frequency Requirements

The first natural frequency of METOP equipment shall be above 100Hz (intended for an equipment mounted on an infinitely rigid interface). In case of equipment containing stowed mechanical parts the requirements can be lowered to 60Hz.

Where this requirement cannot be met the Contractor shall perform specific analysis to support acceptance of the design.

A.4.10.1.13 **Dimensioning Loads**

During the launch, low frequency dynamic and static loads are to be combined to produce the Quasi-Static loads (QSL). In this respect, the flight limit loads encountered by the MXTOP satellite at the given most critical flight events are specified in AD5 and AD6. The design and dimensioning of the METOP Satellite primary structure shall withstand the most severe load combination that can be encountered at any given instant of the flight.

A.4.10.1.14 **Design Life/Fatigue Life**

All mechanical flight hardware shall be capable of surviving a total number of mission cycles at least 2 times greater than the total number of expected applicable mission cycles, including ground operations (handling, transportation and testing).

The factor of two applies also to the fatigue life of the residual load path in case of fail-safe structures.

A.4.10.1.15 **Creep**

The design shall preclude cumulative creep strain leading to rupture, detrimental deformation, or creep buckling of compression members.

A.4.10.1.16 **Thermal Distortion**

The effects of thermal distortions and of thermally induced mechanical stresses shall be taken into account in the mechanical design itself and in the design of all the interfaces.

A.4.10.1.17 **Mounting Brackets**

Where necessary, flexible mounts brackets shall be provided by the METOP structure in order to alleviate any risk of high interface forces and distortion at the interface.

A.4.10.1.18 **Structural Bonding**

The design of the METOP structural parts shall take into account the requirement of electrical continuity between equipment and the structure and between all structural elements.

A.4.10.1.19 **GSE Interfaces**

The METOP Satellite shall be provided with adequate GSE mechanical interface points for ground handling, lifting and transportation either in full launch configuration and in all intermediate assembly configurations as requested to support the AIT activities.

Interface points between MGSE and the Satellite shall be designed as fail-safe.

A.4.10.1.20 **MGSE Safety Factors**

The METOP Satellite MGSE shall be designed by applying the Safety Factors specified in the following table:

Items	**Safety Factors**	
	Yield [a]	**Ultimate [a]**
MGSE	3 [b]	3 [b]
Lifting Devices [c]	3	5 [d]

A-4.10.1.21 **MGSE Interface Forces**

The transmission of forces within the interface contact points between MGSE and any flight interface shall be the same as during flight, except where MGSE dedicated attachment points are fitted to the Satellite.

A.4.10.2 Fluids Selection, Handling and Storaae

A-4.10.2.1 Fluid Design Margin8

The design shall provide for an adequate margin between the operational and fluid phase dependent critical regions. It shall be possible to monitor the margin during operations to preclude hazardous conditions arising.

A-4.10.2.2 Fluid Losses

Fluid losses due to venting, boil-off or over-board dumping shall be controlled events and shall comply with the environmental, contamination and safety requirements. The design shall prevent uncontrolled accumulation of hazardous fluids.

A.4.10.2.3 Fluid operation

The METOP Satellite shall provide the capability, to the extent required by the specified operational scenario, to store, transfer, monitor, manage, service and de-service fluids in a controlled manner.

A.4.10.2.4 Fluid Containers

The design of fluid containers and components shall exclude or minimize fluid dynamic effects.

A.4.10.2.5 Vibrations in Fluid Lines

The design of flexible lines and bellows shall exclude or minimize flow-induced vibrations (see AD16, MSFC-DWG-20M02540 for applicable requirements). Induced motions or moments resulting from fluid transfer dynamics and venting shall be controlled.

A.4.10.2.6 Fluid Handling Equipment

Fluid handling equipment shall implement the specified design safety factors of the flight configuration for all items in this equipment which are in direct contact with these fluids.

A.k.10.3 **Mechanisms**

A.4.10.3.1 Mechanical Design

Mechanisms shall be designed to meet the mechanical interface and performance requirements and to withstand the predicted environment during handling, transportation, testing, storage, launch and orbital lifetime without damage or degradation.

A.4.10.3.2 Strength Requirements

Mechanisms shall be considered as structures as far as strength and stiffness aspects, therefore their design shall comply with the stiffness, strength and, where applicable, fracture control requirements imposed on the other structural components.

A.4.10.3.3 Strength Safety Margins

Mechanisms shall be designed with a positive margin of safety against yielding and against ultimate under all environmental and operational load conditions. In the computation of safety margins the following safety factors shall be used for standard metallic materials:

- yield stress factor of safety: 1.25
- ultimate stress factor of safety: 1.5

Other materials require ESA approval of required safety factors on a case by case basis.

The following specific safety factors apply on the identified components:

- cables, ultimate stress factor of safety: 3
- mechanical stops, shaft shoulders and recesses, against yield: 2

A.4.10.3.4 Torque/Force Ratio

The flight mechanism actuators (electrical, mechanical, thermal and others) shall be designed to provide, throughout the expected operational life and over the full range of travel, actuation torques/forces exceeding at least by a factor of 2 the combined worst case resistive torques/forces in addition to any required deliverable output torque/force. The minimum uncertainty factors defined in the table below shall be applied to the resistance components in order to derive the worst case resistive torques/forces:

Component	Symbol	Uncertainty Factor
Intertia	I	1.1
Mass	M	1.1
Spring	S	1.2
Friction	Fr	3.0 [a]
Hysteresis	Hy	3.0 [a]
Others (Harness)	Ha	3.0 [a]
Adhesion	Hd	3.0

Hence the minimum required actuator torque/force against worst case resistive torques/forces, is defined by the following equations:

Ta =
TL + 2.0*(1.1*I*d^2Q/dt^2+1.2*S+3*Fr+3*Hy+3.0*Ha+3*Hd)

Fa = FL + 2.0*(1.1*M*dV/dt+1.2*S+3*Fr+3*Hy+3.0*Ha+3*Hd)

where TL and FL are respectively the required output torque/load.
Kinetic energy of the moving components shall not be considered in the provision of actuation torque/forces to overcome the resistive torque/forces.

If the mechanism function is achieved/assisted by any of the tabulated resistive components, then the uncertainty factors shall be used as dividing factors rather than multiplication factors.

A.4.10.3.5 Spring Actuator6

When using spring actuators to drive mechanisms, the torque/force ratio requirement shall be met by the design/measured spring torque/force derated by 202.

A.4.10.3.6 Status Monitoring

The design of mechanisms shall include appropriate means to monitor the execution of its main functions. Mission critical mechanisms shall be designed in such a way that a monitoring of its critical function(s) shall be performed by the CCS and telemetered to ground.

The monitoring shall include stowed and deployed conditions and, as appropriate, progress of deployment. As a minimum all phases of the solar array deployment and the ASCAT deployments shall have progress of deployment monitoring.

For any motorised deployment it shall be possible, by ground command, to reverse the deployment direction.

A.4.10.3.7 Latching/Locking

hatching mechanisms used to assure positive locking, either in stowed or deployed condition, shall be designed to avoid inadvertent unlocking by vibration or shock under operating conditions. Locking or latching mechanisms shall be designed to be operable by a single control and shall provide a clear indication of whether the latch/lock is open or closed.

Electrical actuated deployables require positive latching.

The latch capture range must be sufficient to ensure capture of the mechanism over the complete range of temperatures/temperature gradients and manufacturing tolerances.

Where latching is not achieved on initial completion of motion, the design shall not prevent subsequent successful latching.

Latches must be simple and self-locking and must be easily resettable for ground testing. Off load mechanisms shall be capable of being operated manually for protection during handling and transportation.

A.4.10.3.0 End Stops

Mechanisms with restricted travel/rotation shall be provided with regular or emergency mechanical end stops to limit the motion and travel extremes to the maximum position for proper functioning of the actuated item and to prevent interference with interfacing equipment. The mechanical stops and arrested mechanism shall be designed to withstand without damage the maximum shock loads possible. The shock loads shall be compliant with the requirements on adhesion forces. Contact with a stop shall not result in a non-recoverable situation.

Electrical deployment indicators (e.g. micro switches) shall not be used as mechanical end stops.

A.4.10.3.9 Separable Contact Surface8

Separable contact surfaces shall be designed to minimize the adhesion force in all events. The contact between the mating surfaces shall be well-characterized and reproducible, especially for the area of contact, alignment and load conditions.

The Hertzian contact pressure shall be demonstrated to be below 50% of the yield limit of the weakest material.

Sliding at the separable contact surfaces shall be avoided as far as possible. Where not possible, lubricated hard surface coatings shall be applied to prevent fretting.

The torque/force ratio of the actuator which separates the contact surfaces shall be demonstrated by test to provide 3 times the worst possible adhesion force in representative environmental conditions.

ground and on orbit (including self-induced environments).

This may be achieved by either:

a) Directly withstanding the applicable thermal environment or

b) Protecting from environment by specific thermal control means.

Thermal design shall be verifiable by analysis or test.

A.4.11.2 Thermal Desiqn Life

The METOP Satellite thermal design shall cover the complete nominal and contingency operating mode range as defined in the Operations scenario.

A.4.11.3 Coatinqs Deqradation

Thermal coatings of the METOP Satellite shall have limited degradation, and the thermal design shall be consistent with the worst case degradation over the planned orbit-life.

A.4.11.4 Mechanisms Thermal Desiqn

The thermal design of mechanisms shall take into account the need for representative thermal vacuum testing to verify the design.
Thennomechanical interfaces shall be designed to minimize the induced stress and to improve the thermal isolation if necessary.
Designs which preclude simulation of orbital thermal conditions during ground testing shall be avoided.

A.4.11.5 Instrument Thermal Requirements

The METOP Satellite thermal design shall allow the accommodation of two different categories of instrument:

a) thermally integrated instruments, i.e. instruments whose temperature is fully controlled by the Satellite Thermal Control during all orbital phases
b) thermally decoupled instruments, i.e. instruments which are, as far as possible, thermally isolated from the satellite and have means for self-thermal controlling (only power provided to the instrument by the Satellite). For this type of equipment there shall be controlled interfaces between equipment and Satellite, which may include some dedicated thermal control by the Satellite.

A-4.11.6 Externallv Mounted Instruments

Externally mounted instruments shall be treated as thermally decoupled equipment, i.e. they shall be thermally isolated from the METOP Structure to the maximum extent practicable whilst, at the same time, respecting the applicable structural requirements.

A.4.11.7 Non-Ooeratins Temoeratures

The METOP Satellite thermal control shall guarantee that, during Payload Off or Instrument Off phases, each equipment survival temperature is maintained.

A.4.11.8 **Thermal Design Optimisation**

The thermal design shall be optimised to achieve the required performances with the minimum resources allocation. Where heaters are used, the heater design and method of operation shall be such as to minimise both the heater power requirements, the number of commandable switches and the frequency of operation.

A.4.11.9 **Thermal Design Margin**

The METOP Satellite thermal control shall be designed with sufficient margin to allow final trimming if needed after system thermal qualification tests.

A.4.11.10 **Surface Thermal Properties**

Thermo-optical properties and temperatures of METOP Satellite surfaces which affect the overall Satellite induced thermal environment with self-induced emitted and/or reflected radiative heat fluxes shall have limited variations over the METOP satellite lifetime, in order to minimise differences between beginning and end of life performances.

A.4.11.11 **Thermal Failure Mode Operations**

The METOP Satellite shall have the capability of detecting and overcoming / isolating the following failures, for continuation of nominal flight operations:

- failures of the thermistors used for heater control and/or temperature monitoring;
- open circuit/short circuit failures of the heater lines;
- violation of temperature limits.

The thermal control system shall be tolerant to independent heater line failures.

A.4.11.12 Independence

The METOP Satellite thermal control shall be flexible enough to guarantee the METOP continuation of nominal flight operations also in case of a selected worst case combination of nominal and failure modes among the Payload Instruments.

A.4.11.13 **Temperature Monitoring**

Flight electrical/electronic equipment dissipating more than 10 watts average shall be instrumented with at least one temperature monitor mounted close to the area of highest dissipation.

A-4.11.14 **Measurement Point Optimisation**

The thermal design shall allow the minimization of the total number of measurement points required, whilst providing sufficient flight temperature measurement points in order to have a non ambiguous status of the correct functioning of the thermal control subsystem.

A.4.10.3.10 Mechanism Lubrication

Mechanisms shall only employ lubricants which are space-qualified according to ESA product assurance requirements.

Dry lubrication is preferred.

Liquid lubricated systems shall be sealed to prevent outgassing, creeping and possible sources of contamination.

A.4.10.3.11 Ball Bearings

If ball bearings are used, they shall be pre-loaded. Pre-loading shall be applied by solid pre-load or produced by compliant loading techniques which do not require sliding at the bearing mounting interfaces.

A.4.10.3.12 Gear8

The dimensioning, sizing and verification of gears shall be performed according to the international standard ISO/DIS/6336 and its reference documents.

A.4.10.3.13 Clearances

When design and locating movable, actuating, or similar mechanisms, adequate clearance shall be provided to prevent:

- interference (collision) with the structure;
- contact with electrical wiring and components, thermal insulation, or other subsystem components;
- puncture of fluid lines, valves and tanks.

A.4.10.3.14 Design Life/Fatigue Life

The lifetime of a mechanism for design purposes shall be determined by using the sum of the predicted nominal ground test cycles and the in-orbit operation cycles and by multiplying the predicted number by the factors indicated in the following table:

Type/Number of Predicted Cycles	Factors
Ground Testing: number of on-ground test cycles (minimum 10)	x 4
In-Orbit Predicted Cycles [a]:	
1 to 10 actuations	x 10
11 to 1000 actuations	x 4
1001 to 10000 actuations	x 2
> 10000 actuations	x 1.25

As actuation, a full output cycle or full revolution of the mechanism is defined.
Any element in a chain of actuation (motor, bearing, gear, etc.) has to be compliant with the maximum number of cycles applicable to any of the remaining elements in the chain.
The lifetime of a mechanism shall be demonstrated by test in the appropriate environment.

A.4.10.3.15 Pyrotechnics

Mechanisms shall allow re-installation and verification of pyrotechnics without need for major disassembly of the mechanism when integrated on the satellite.
All pyrotechnic and other release devices shall be redundant. Redundancy shall be provided by duplication up to and including the level of the initiators, heating element or equivalent for non-pyrotechnic devices, and relevant power supplies.

As a minimum, properties such as strength, shock impulse, redundancy, performance output, sealing and operation at temperature extremes under vacuum must *have* demonstrated their performance requirements.
The operation of release devices shall be compatible with the cleanliness requirements and shall not endanger the operation of the mechanism due to debris generation. Suitable means of debris containment shall be included if necessary.

A.4.10.3.16 **Mechanisms** Redundancy

Redundancy concepts shall be selected to minimise single points of failure and to optimise reliability for the mission. Where a single point of failure is identified and redundancy cannot be provided, the required reliability shall be demonstrated. Active elements of mechanisms such as sensors, motors, actuators, switches and electronics shall be redundant. Failure of one element shall not prevent the other from performing its intended function, nor the equipment from meeting its performance requirements.

A.4.10.3.17 **Mechanisms** Verification

The mechanisms analytical verification shall include functional performance analyses in all possible environments for all operational conditions. The mechanisms analysis shall include worst operation case identification.
All flight mechanisms shall be designed to allow ground verification testing of their orbital configuration. The mechanism design shall be compatible with operation in ambient and thermal vacuum conditions.
Tests shall be performed to check Mechanisms performances in both launch and operational configurations.

A.4.11 THERMAL DESIGN REQUIREMENT

A.4.11.1 Overall Thermal Requirements

The METOP Satellite shall be designed to withstand, operate and perform *as* specified, in the natural and induced environments which it will experience throughout its lifetime, both on

A.5 INSTRUMENT REQUIREMENTS

A.5.1 METEOROLOGICAL INSTRUMENTS

In the following Sections the descriptions and performance characteristics-are for information only.

Note however that the DCS antenna and associated RF accessories are is not part of the CFE and shall be provided by the Contractor. They are specified in AD19.

A.5.1.1 MHS

A.5.1.1.1 Description

MHS is a five channel self calibrating microwave scanning radiometer. The channels in the frequency range 90 to 190 GHz provide a humidity profiling capability. The measured signals are also sensitive to:

- liquid water in clouds and hence can be used to measure cloud liquid water contents;
- graupel and large water droplets in precipitating clouds and hence can provide a qualitative estimate of precipitation rate.

A-5.1.1.2 Performance Characteristics

Channel	Centre Frequency (GHz)	Max. Bandwidth (MHz)	Temperature Sensitivity (K)
2	15700	2800	1.0 1.0
IL	1183.311 +/- 1.0	1000	1.0
4	183.311 +/- 3.0	2000	1.0
5	183.311 +/- 7.0	4000	1.0

A.5.1.1.3 Interface Requirements

The interface requirements of this instrument are specified in AD34.

A.5.1.2 AMSU Al

A.5.1.2.1 Description

AMSU-A is a 15 channel instrument, consisting of two separate modules, AMSU-Al and AMSU-A2.

AMSU-Al is a 13 channel (numbers 3-15) scanning microwave instrument which is used to obtain data to calculate temperature and humidity profiles of the atmosphere from the Earth's surface up to the stratosphere.

AMSU-A1 has 2 scanning reflectors with momentum compensation and provides sounding in 13 channels. The footprint at nadir is 50 km. The scanner has 30 Barth pointing positions with a separation of 3.333 deg between them, 1 cold calibration position, and 1 warm calibration position. A full scan takes 8 seconds.

A.5.1.2.2 **Performance Characteristics**

Channel	Centre Frequency (GHz)	Bandwidth (MHz)	NE Delta T (K)
3	50300	180	0.4
4	52800	400	0.25
5	53596 +/- 115	170 /2 p.b.	0.25
6	54400	400	0.25
7	54940	400	0.25
8	55500	330	0.25
9	57290.344 = Flo	330	0.25
10	Flo +/- 217	78	0.4
11	Flo +/- 322.2 +/- 48	36	0.4
12	Flo +/- 322.2 +/- 22	16	0.6
13	Flo +/- 322.2 +/- 10	8	0.8
14	Flo +/- 322.2 +/- 4.5	3	1.2
15	89000	6000	0.5

A.5.1.2.3 Interface **Requirements**

The interface requirements of this instrument are specified in AD34.

A.5.1.3 AMSU A2

A.S.1.3.1 **Description**

AMSU-A2 is a two channel scanning microwave instrument (channel numbers 1 and 2), which is used to obtain data to calculate temperature and humidity profiles of the atmosphere from the Earth's surface up to the stratosphere.

AMSU-A2 has one rotational scanning reflector without momentum compensation and provides sounding in 2 channels. The footprint at nadir is 50 km. The scanner has 30 Earth pointing positions with a separation of 3.333 deg between them, 1 cold calibration position, and 1 warm calibration position. A full scan takes 8 seconds.

A.5.1.3.2 Performance Characteristics

Channel	Centre Frequency (MHz)	Bandwidth (MHz)	NE Delta T (K)
1	23800	270	0.3
3	31400	180	0.3

A.5.1.3.3 Interface Requirement8

The interface requirements of this instrument are specified in AD34.

A.5.1.4 AVHRR/3

A.5.1.4.1 Description

The Advanced Very High Resolution Radiometer, AVHRR/3 scans the Earth surface in six spectral bands in the range of 0.7 - 12 microns.

It provides day-night imaging of land, water and clouds, measures sea surface temperature, ice snow and vegetation cover and characteristics.

AVHRR/3 has an instant foot print in nadir of 1.1 km. Scanning is cross-track with a total field of view of +/- 56 deg about nadir. Instrument's detectors are passively cooled to less than 100 K. The instrument uses an internal rotational scanning mirror which also views deep space and an internal calibration source.

A.5.1.4.2 Performance Characteristics

Channel	Central Wavelength (microns)	Half Power Points (microns)	Channel Noise
1	0.630	0.58 - 0.68	S/N 9:1 @ 0.5% albedo
2	0.862	0.725 - 1.00	S/N 9:1 @ 0.52 albedo
3a	1.61	1.50 - 1.64	S/N 20:1 @ 0.5% albedo
3b	3.74	3.55 - 3.93	0.12K @ 300 K
4	10.80	10.30 - 11.30	0.12K @ 300 K
5	12.00	11.50 - 12.50	0.12K @ 300 K

A.5.1.4.3 Interface Requirement8

The interface requirements of this instrument are specified in AD34.

A.5.1.5 HIRS/3

A.5.1.5.1 Description

The High Resolution Infra-Red Sounder, HIRS/3, which scans the Earth surface in twenty spectral bands in the range of 0.69 - 14.95 microns.

It provides data for temperature - altitude profiles, moisture content, cloud height and surface albedo.

HIRS/3 has an instant foot print in nadir of 20 km. Scanning is cross-track with a total field of view of +/- 49.5 deg about nadir. Instrument's detectors are passively cooled to 100 K.The instrument uses an internal step scan mirror which scans in 1.8 deg increments at a set rate of 10 steps per second.

A-5.1.5.2 Performance Characteristics

The sensitivity, as noise equivalent spectral radiance, NE delta N, in mW/(m^2 ST cm^-1)is given in the following Table

Channel	Wavelength (microns)	Sensitivity NB Delta N
1	14.95	3.00
2	14.71	0.67
3	14.49	0.50
4	14.22	0.31
5	13.97	0.21
6	13.64	0.24
7	13.35	0.20
8	11.11	0.10
9	9.71	0.15
10	12.47	0.15
11	7.33	0.20
12	6.52	0.20
13	4.57	0.006
14	4.52	0.003
15	4.47	0.004
16	4.45	0.004
17	4.33	0.002
18	4.10	0.002
19	3.76	0.001
20	0.69	0.10% albedo

A.5.1.5.3 Interface **Requirements**

The interface requirements of this instrument are specified in AD34.

A.5.1.6 **DCS**

A.5.1.6.1 Description

The Data Collection System, DCS, known also as ARGOS, collects data from platform transmitters (PTTs) located on continents and oceans in VHF frequency.

Marine PTTs located on buoys transmit oceanographic data, ship PTTs weather data and oceanographic data, land based PTTs provide meteorological and hydrological data and those on balloons atmospheric data.

The DCS uses Doppler information to determine the location of PTTs. The data are stored on board the satellite for later transmission to ground.

The DCS system consists of:

- Receive and Power Unit
- Signal Processing Unit
- One VHF receive antenna UDA (which is not a part of the CFE, and is specified in AD19)

A.5.1.6.2 Performance **Characteristics**

- Receive Frequency: 401.65 MHz
- Receiver Bandwidth (1dB): 80 kHz
- MDS: -108 to -131 dBm
- Frequency Stability: 2 x 10^{-9} over TBD sec.
- Receive antenna (UDA): quadrifilar helix antenna
- Max. gain: +6 dBi at 60 deg off nadir, -3 dBi at nadir

A.5.1.6.3 Interface **Requirements**

The interface requirements of this instrument are specified in AD34.

A.5.2 OP<u>TIONAL NOAA-PROVIDED INSTRUMENTS</u>

In the following Sections the descriptions and performance characteristics are for information only.

The S&R antenna and harness shall be provided by the Contractor.

A-5.2.1 <u>Search and **Rescue Processor**</u>

A.5.2.1.1 **Description**

The system acts as a transponder and distress locator for SARSAT distress terminals.

The Search & Rescue Processor (SARP) receives and processes emergency signals from emergency locator transmitters (ELTS) located on downed aircraft and receives signals from Emergency Positions Indicating Radio Beacons (EPIRBS) located on ships.

SARP emergency data is transmitted to a ground station network called Local User Terminals (LUTS) via the Search & Rescue Repeater (Chapter 5.1.8) when the repeater is within the range of a ground station.

The LUTS forwards data to a mission control centre which then notifies rescue forces.

SARP measures received frequencies, allowing the use of Doppler Processing. It uses a memory to store global data for later transmission to ground stations.

Local area data are sent immediately.

SARP consists of two boxes: a Receiving and Power Unit (RPU) and a Signal Processing Unit (SPU).

A.5.2.1.2 Performance Characteristics

SARP receives signals from ELTS and EPIRBs transmitters via the UDA antenna from DCS.

- Receive Frequency: 406.05 MHz
- Receiver Bandwidth (1dB): SO kHz
- Dynamic Range: -108 to -131 dBm
- Doppler Accuracy: 0.35 Hz (rms)
- Bit Error Rate: < 2 x 10^-5
- Frequency Stability: TBD
- Probability of good signal processing: 0.99
- Probability of correctly processing multiple beacons in one pass: 0.95

A.5.2.1.3 Interface Requirement8

The interface requirements of this instrument are specified in AD34.

A.5.2.2 Search and Rescue Repeater

A.5.2.2.1 Description

The Search and Rescue Repeater, SARR, receives and downlinks emergency signals from downed aircraft and ships.

In addition, it provides a down path for global area data received by the Search and Rescue Processor (SARP).

SARR receives signals on three separate frequencies from emergency local transmitters (ELTS) and emergency position indicating radio beacons (EPIRBS) located on ships in distress.

The SARR transmitter operates at L-band and its signal is received by Local User Terminals (LUTS), which process the data and forward it to a mission control centre (MCC).

SARR receives function to recover local area signals only and can only be used within range of a LUT.

All local area signal processing including location by Doppler is done at the LUT. Global area data from SARP is already pre-processed.

SARR consists of two assemblies: a transmitter and a receiver section.

It receives the RF signals via a VHF antenna called SRA.

A.5.2.2.2 **Search And Rescue Repeater (Receiver)**

A.5.2.2.2.1 Descrintion

The receiver of the Search and Rescue Repeater receives signals at three VHF frequencies via one antenna (SRA). It accepts also a digital input from the SARP at a rate of 240 BPS.

The receiver section of SARR consists of there receivers.

A.5.2.2.2.2 Performance Characteristics

The SARR has the following performance characteristics.

Frequency (MHz)	Bandwidth **(MHz)**	**Dynamic Range (dBm)**
121.5	+/-12.5	-149 to -108
243.0	+/-32.0	-152 to -110
405.05	+/-40.0	-145 to -107

.&.5.2.2.2.3 Interface Reauirements

The interface requirements of this instrument are specified in AD34.

A.5.2.2.3 **Search And Rescue Repeater** (Transmitter)

A.5.2.2.3.1 Descrintion

The three receiver outputs are frequency translated to provide sideband separation before phase modulating the down link L-band transmitter. SARP data is modulated directly on the carrier without translation. Provision is made to maintain a constant value of the modulation index.

A.5.2.2.3.2 Performance Characteristics

- Carrier Frequency: 1544.5 kHz
- Bandwidth (RF): +/-3.2 kHz
- EIRP (nadir): TBD
- Polarisation: LHC
- Application Data Stream: data from SARP SARR
- Antenna: SLA antenna

A.5.2.2.3.3 Interface Requirements

The interface requirements of this instrument are specified in AD34.

A.5.2.3 SEM

A-5.2.3.1 Description

The Space Environmental Monitor, SEM, is a multichannel charged-particle spectrometer, which senses the flux of charged particles from the Sun's ionised plasma (at the satellite altitude) and contributes to the solar terrestrial energy knowledge.

SEM consists of three major components:

- Total Energy Detector (TED)
- Medium Proton and Electron Detector (MEPED)
- Data Processing Unit (DPU).

TED uses swept electrostatic curved-plate analyses with channeltron detectors to select the particles types and electrons.

MEPED has two sets of proton and electron telescopes and an omnidirectional detector.

The DPU provides timing and control, analog and digital multiplexing, particle detector data processing, A/D conversion, data and command processing and is the electrical interface between TED and MEPED and the satellite.

A.5.2.3.2 **Performance Characteristics**

TED measures the total directional energy flux of electrons and positive ions travelling from the anti-earth direction, and at 30 deg to the anti-earth direction.

- Energy range: 50 eV to 20 keV.
- Counting rate: 5 x 10^5 (pps)
- Sampling interval: 2sec
- No. of channels: 5

MEPED senses protons, ions and electrons. Its sensors look in the anti-Earth direction and at 90 deg off nadir.

- Energy range: 30 eV to 140 MeV
- Counting rate: 5 x 10^7 (pps)
- Sampling interval: 2 sec
- No. of channels: 12

A.5.2.3.3 **Interface Requirements**

The interface requirements of this instrument are specified in AD34.

A.5.3 AO INSTRUMENTS

In the following Sections the descriptions and performance characteristics are for information only.

A.5.3.1 IASI

A.5.3.1.1 Description

IASI is an Infrared Fourier Transform Spectrometer performing a night and day passive remote sensing of the atmosphere within 3.5 to 15.5 microns range. IASI includes an "integrated imaging system" which allows characterisation of cloudiness inside the IFOV.

The total FOV is +/- 49 deg. from nadir.

Measurements on cold reference targets (two views to the space are accommodated) and hot reference target (on-board black body) are taken every 8 seconds for the updating of calibration tables.

A.5.3.1.2 **Performance Characteristics**

IASI transmits to the Earth calibrated spectrum of the atmospheric column with:

- 25 km sampling distance at sub satellite point
- 0.25 cm^-1 unapodised spectral resolution (0.01 cm^-1 absolute accuracy)
- 1 K absolute radiometric accuracy.

A.5.3.1.3 Interface Requirements

The interface requirements of this instrument are specified in AD34.

A-5.3.2 OMI

A.5.3.2.1 Description

The OMI is a nadir-viewing spectrometer which will observe solar radiation transmitted or scattered from the Earth's atmosphere or from its surface. The recorded spectra will be used to derive a detailed picture of the atmosphere's content and profile of ozone, nitrogen dioxide, water vapour, oxygen/oxygen dimer and other gases.

OMI's instantaneous field of view is 40 km x 2 km, equivalent to 2.8 deg x 0.14 deg. The instrument uses a scanning mirror which scans across the satellite's track. With +/-31 deg. scan, global coverage can be achieved within 3 days.

A.5.3.2.2 Performance Characteristics

Band	Wavelength (nm)	Pixel Resolution (nm)	Spectral Resolution (nm)
1A	240 - 268	0.11	0.22
1B	268 - 295		
2A	290 - 312	0.12	0.24
2B	312 - 405		
3	400 - 605	0.2	0.4
4	590 - 790	0.2	0.4

A-5.3.1.3 Intarf **ace Requirements**

The interface requirements of this instrument are specified in AD34.

A.5.3.3 **ScaRaB**

A-5.3.3.1 **Description**

The Scanner for Radiation Budget, ScaRaB, is a four channel cross track scanning radiometer. The four spectral ranges are realised using filters and pyro-electrical detectors.

SCARAB measures in the spectral range from 0.5 to 12.5 microns.

It determines the radiation budget of the Earth atmosphere system.

A.5.3.3.2 **Performance Characteristics**

Channel	Spectral Region (microns)	Remark
1	0.5 - 0.7	visible
2	0.2 - 4	solar
3	0.2 - 50	total
4	10.5 - 12.5	atmospheric window

A.5.3.3.3 Intarf **ace Requirements**

The interface requirements of this instrument are specified in AD34.

A.5.4 CONTRACTOR PROCDRXD INSTRUMENTS

A.5.4.1 MIMR

This section defines the overall requirements to be fulfilled by the Multifrequency Imaging Microwave Radiometer (MIMR) instrument. Prior to the establishment of the MIMR Instrument Design and *Performance* Specification (DRL MI-21 then AD30 shall be used as a guideline for the detailed instrument requirements.

MIMR is a conical scanning, Multi-frequency Imaging Microwave Radiometer which shall image the Earth with 6 channels in both horizontal and vertical polarisations.

The radiometer measures the brightness temperature, which is related to the emissivity of the Earth surface and its atmosphere. The emissivity of the Earth depends upon dielectric properties of the surface materials and atmospheric propagation effects, all frequency and incidence angle dependent.

By reconstituting the brightness temperature field over the Earth at selected frequencies and using empirical or mathematical models, geophysical parameters such as rain rate, sea surface temperature, sea ice wind speed etc. can be retrieved.

MIMR output products are of prime importance for an all weather monitoring of the environment, and will provide useful data for climatology and meteorology with day and night operation capabilities and near daily global coverage.

MIMR will contribute to:

1 **Environment**

- *monitoring* and prediction of the global environment (GEWEX, TOGA, WOCE, etc.);
- monitoring climate and climate change (GCOS).

2 Resource **Management**

- snow and ice:
- forestry.

3 Meteorology **(WWW)**

- operational meteorology;
- convection and precipitation;
- surface/atmosphere interactions.

A.5.4.1.1 Orbit and Attitude

Orbit and attitude requirements are defined in Section A.4.3; MIMR shall be required to fully meet its performance requirements only in the reference orbit defined there.

A-5.4.1.2 Reference Operation **Profile**

The instrument shall be operated continuously over each full orbit.

A.5.4.1.3 **Time Management**

Datation and eynchronisation of instrument data shall be in accordance with Section A.4.6

A.5.4.1.4 **General** Operability

In accordance with Section A.4.4.

A.5.4.1.5 **Functional requirements**

The functions to be ensured by the instrument shall include:

- detection and data acquisition of signals from the earth, and relevant calibration measurements;
- data flow packetisation and transmission to the Payload Data Handling and Transmission subsystem of the spacecraft including datation;
- interfacing to the CCS of the spacecraft for the acquisition, scheduling, expansion, and verification of the instrument telecommands as well as for the acquisition, monitoring, autonomous control and reporting of the instrument health and configuration status, as specified in Section A.4.4;
- power conversion and distribution for the MIMR internal equipments;
- thermal control;
- mechanical structure, mechanisms to satisfy the mission and the operational requirements.

A-5.4.1.6 operational *requirement8*

The instrument shall be compatible with any satellite mode, all mission phases and shall function during routine mode changes of other instruments.

The instrument shall not obstruct other instrument fields-of-view when in stowed configuration or during deployment or when operating.

Besides the nominal modes of operation, the following specific instrument support modes shall be considered and defined as necessary:

- launch mode with no or very limited power consumption;
- safe/survival modes ensuring the safeguard of the instrument when the satellite is not operating nominally;
- non-operation (standby) mode minimizing the power consumption when the instrument is not operating in its normal or calibration modes;
- back-up mode ensuring the safe instrument survival in case of **severe** instrument failures, e.g. failure

in the instrument control unit.

Calibration modes (TBC) shall be considered for the execution of the in-flight instrument calibration required to achieve the instrument performance.

The initial switch-on phase of the instrument shall be designed such that the transition from standby to operational mode, during which the rotation motor spins up, shall be performed in optimum ground station visibility.

The design of the instrument shall be such that its final mechanical balancing in orbit is made via ground control command. In this remote control mode, the telemetries and commands necessary to operate the instrument shall be compatible with the Commissioning Phase planning.

A.5.4.1.7 Design requirement8

The instrument shall be designed in accordance with Section A.4.6 Section A.4.9, Section A.4.10 and Section A.4.11.

Auxiliary data necessary to interpret or use the observational data shall be contained in the science data stream.

A.5.4.1.8 MIMR Performance Requirements

A.5.4.1.9.1 Definition of ImpulseResponse Function and Modulation Transfer Function

The Impulse Response Function, IRF, h(u,v) is specified as the two-dimensional response to a point target. The u and v parameters are the along and across track coordinates measured on the surface of the Earth reference ellipsoid.

The two-dimensional spatial resolution (resolution cell) is defined in the principal cut in each of the along track and across track directions on the sub-satellite track, and is given by the width of the impulse response function (IRF), where the intensity reaches 50% of the peak value. This spatial resolution cell may rotate with the conical scan.

The modulation transfer function, MTF, H(U,V) is specified as the Fourier transform of the impulse response function. U and V are the spatial *frequencies* of the MTF *in* the along and across track cuts, and are expressed in km^-1. The MTF of the space segment characterises the spatial transfer function of the onboard Science Data Chain. This space segment MTF shall include, in a non exhaustive list, the effects of the antenna pattern, the detector, the on-board integrator, the sampling, the altitude/attitude variations, the scanning, and the on board digital processing parameters.

The two-dimensional spectral resolution is given by the width of the modulation transfer function, where the spectral intensity reaches 50% of the peak value.

A.5.4.1.8.2 Radiometric Performance

The required radiometric performance is given in the following Table.

Channel	Radiometric Sensitivity (K)	Radiometric Stability (K)	Radiometric Accuracy (K)
1	0.2	0.2	1.0
2	0.4	0.4	1.0
3	0.5	0.5	1.5
4	0.5	0.5	1.5
5	0.5	0.5	1.5
6	0.7	0.7	1.5

Radiometric sensitivity, or Noise Equivalent delta Temperature (NE delta T), is defined as the minimum detectable change of the brightness temperature incident at the antenna collecting aperture. The NE delta T values shall be defined as the standard deviation of the radiometer output in degrees Kelvin (K) when the antenna is viewing a 300 K uniform target, except for channels 1 and 2 where 150 K will be considered. For the radiometric sensitivity computation, the integration time shall be defined as the dwell time needed by the beam to cross a pixel, whose dimension would be equal to the along track footprint size defined by the half power beam width.

Radiometric stability shall be defined as the time-varying component of the radiometric error in the MIMR measurement. It comprises the short term and long term variations over an integration period sufficient to remove the radiometric signal variations.

Radiometric accuracy shall be defined as the time-invariant part of the radiometric error in the MIMR measurement. Accuracy is representative of deterministic errors of parameters, affecting with a bias the mean inferred brightness temperature (where fluctuations cancel).

The sum of the radiometric accuracy and radiometric stability provide the difference between the brightness-temperature inferred from the microwave radiometer observing a blackbody test scene and the brightness temperature of this blackbody target.

A.5.4.1.8.3 Aliasing definition

Aliasing effect is due to instrument sampling frequency constraints which limit the higher spatial frequency content of the MTF of the instrument. It is defined as the error between the instrument output not sampled and the instrument output re-constructed by using the available samples, all quantities excluding any stability and accuracy errors as defined in Section A.5.4.1.8.2. Aliasing figure shall be expressed in percentage.

A.5.4.1.0.4 Sampling distances

This requirement defines the on-board sampling as provided by the instrument at its interface with the platform. Sampling shall be such that its contribution to aliasing errors is minimized, yet it shall be compatible with the other requirements of this specification and in particular with the instrument data rate limit of Section A.5.4.1.12.2.

1 Along track: the sampling distance in the along track direction is governed by the on ground speed of the spacecraft (altitude dependent) and the rotation rate of the antenna. Antenna scanning shall be such that along track equisampling is provided.

2 Across track: the distance between two samples across track is governed by the scan rate and the selected sampling time.

As a result of previous studies, the preferred sampling scheme is as indicated in the following Table.

Channel	Sampling Distance along-track (km)	Sampling Distance across-track (km)
1	13.2	14.8
2	13.2	7.4
3	13.2	7.4
4	13.2	7.4
5	6.6	3.7
6	3.3	1.9

A.5.4.1.0.5 System dynamic range

The performance requirements shall be met over the full dynamic range.

The dynamic range of the radiometer channel shall be from 2 K to 330 K without the need for any ground telecommanded offset adjustment in the measurement chain during nominal flight operating conditions.

A-5.4.1.0.6 Incidence Anal?

The angle between the beam electrical boresight direction and the normal to Earth surface at the point of interception of this boresight direction with the Earth surface shall be 55 deg (TBC).

A.S.4.1.8.7 Swath width

The imaging swath shall be greater than 1600 km (TBC).

Due to possible offsets of the swath with respect to the sub-satellite track the gaps in coverage, leading to non-imaged caps at the poles may be different in the two polar regions. Neither cap shall exceed 500km in diameter (TBC).

A.5.4.1.8.8 Localisation

After ground processing, the data shall be calibrated to within the radiometric accuracy and stability requirements and geometrically corrected such that the centre of any channel can be located in Earth coordinated to +/-2 km (TBC).

A.5.4.1.9 Channel Assignment and Requirement8

The MIMR instrument shall be a 6 channel total power microwave radiometer including both vertical and horizontal polarisations for all channels. This section specifies the requirements of the receiver channels defined as the subsystem whose inputs are the collecting apertures of the receivers (the horns) and whose outputs are the digital data as transmitted to the PDHS.

A.5.4.1.9.1 Frequency

The following Table lists the centre frequency channel assignment to be used for the MIMR instrument.

Channel	Centre Frequency (GHz)	Frequency Stability (MHz)
1	6.8	5
2	10.65	5
3	18.7	10
4	23.8	20
5	36.5	20
6	89	20

The frequency stability listed in the Table is the maximum deviation from the channel centre frequency for both short-term periods and over the operational life.

A.5.4.1.9.2 Receiver channel protected bandwidth

The following Table, based on the CCIR frequency/bandwidth allocation for passive radiometry, specifies the protected RF-bandwidth to be used for each channel. All channels are specified in Section A.S.4.1 9.1 at the centre frequency of the allocated bandwidth.

Channel	Channel Bandwidth (MHz)
1	200
2	100
3	200
4	400
5	1000
6	6000

A.5.4.1.9.3 Input amplifier max Dower

The front end amplifiers of the MIMR receiver chains shall withstand without subsequent degradations a maximum input power level of 10dBm (TBC).

A.5.4.1.10 **Antenna requirements**

A.5.4.1.10.1 Antenna Beamwidth

The half power antenna beam width in its larger dimension shall comply with the following Table. The beam width accuracy for design and characterisation shall be better than +/-1%.

Channel	Antenna Beamwidth (deg)
1	2.16
2	1.38
3	0.80
4	0.73
5	0.42
6	0.174

A.5.4.1.10.2 Beam Efficiency

The antenna beam efficiency shall be better than 95% over the main beam region (2.5 x 3 dB beamwidth) and 97% or better over the main beam and its near sidelobe region (7.5 x 3 dB beamwidth) for all channels and all beam positions.

A-5.4.1.10.3 Spill-Over

The power corresponding to the feedhorn pattern not subtended by the main reflector shall not exceed 2.5% (TBC) of the total power received by the feedhorn.

A.5.4.1.10.4 Polarization

A.5.4.1.10.4.1 Type

There shall be one pair of linear, orthogonal polariaations (vertical and horizontal) for each channel.

A.5.4.1.10.4.2 purity

The polarization purity is defined as the ratio, expressed in decibels, between the copolar energy and the crosspolar energy in a solid angle corresponding to 7,5 times the half power beam width. The polarization purity shall be better than 21 dB (TBC) when all contributions due to reflector, feed, OMT and instrument pointing are included.

A.5.4.1.10.4.3 Orientation

The vertical polarization shall remain in the plane of incidence for all scanning positions.

A.5.4.1.10.4.4 Polarimetric Capabilities (TBC)

A polarisation channel (for potential measurement of winds vectors over ocean) shall be provided as an alternative to the high-resolution capabilities of channel 5 (36.5 GHz). The centre frequency and bandwidth capabilities shall be as the nominal channel 5 values, the beamwidth and sampling shall be as channel 3, and the polarisation shall be H, V and +45 deg and -45 deg.

A.5.4.1.10.5 Pointing

The antenna pointing direction shall be compliant with Section A.5.4.1.8.6. The error introduced into the overall beam pointing budget by the MIMR instrument itself shall not exceed 300 arc-sec. including bias and instabilities.

A.S.4.1.11 Calibration

A.5.4.1.11.1 In-flight calibration

External calibration shall be based on a calibration reflector looking at the cold space and a hot calibration target both viewing the feed horns used in nominal measurement mode.

The "hot" calibration target shall be at nominally 300 K and thermally controlled/stabilised as necessary.

A.5.4.1.11.2 Calibration accuracy and stability

Radiometric calibration performance shall be adequate to meet the overall performance requirements given in Section A.5.4.1.8.2.

A.5.4.1.11.3 Calibration antenna nointing

The cold-calibration antenna beamwidth and pointing direction, shall be defined in order to meet the MIMR system parameter requirements (radiometric accuracy and stability).

The accuracy and knowledge of this antenna pointing shall be better than 0.5 deg.

A.5.4.1.12 Interface requirements

A.5.4.1.12.1 Reference frame

The instrument/subsystem equipment reference frame shall be aligned to the satellite reference frame and shall have the same positive direction.

A.5.4.1.12.2 Electrical interfaces

MIMR shall comply with Section A.4.9.

The power consumption of MIMR shall be less than 170 W in operating mode, with a target figure of 150W.

The data rate of MIMR in nominal operating conditions shall be less than 100 kbit/s.

A.5.4.1.12.3 Mechanical requirements

MIMR shall comply with Section A.4.10.

The mass of MIMR shall be less than 160 kg.

The residual momentum shall be less than 0.5 Nms per each axis.

The static imbalance in nominal operating conditions shall be less than 3.54 kg.mm.

The dynamic imbalance in nominal operating conditions shall be less than 5474 kg.mm2.

The static and dynamic imbalances during satellite manoeuvre shall be less than three times the values allowed in nominal operating conditions.

The static and dynamic imbalances, during ramp-up and ramp-down of the scanning mechanism, shall be less than two times the values allowed in nominal operating conditions

The residual torques (constant *torque,* sinusoidal torque, white noise torque) in nominal operating conditions at instrument to platform interfaces shall be compatible with the Satellite AOCS design (the requirements of the MIMR instrument interface specification for a generic spacecraft, AD36, can be used as preliminary values).

During deployment the impulse torque shall be compatible with the Mission requirements.

A.5.4.1.12.4 Thermal Desicm Requirements

MIMR shall comply with Section A.4.11.

A.5.4.2 ASCAT

This section defines the requirements to be fulfilled by the Advanced Scatterometer instrument, ASCAT. Prior to the establishment of the ASCAT Instrument Design and Performance Specification (DRL AS-2) then AD31 shall be used as a guideline for the detailed instrument requirements.

ASCAT will allow measurement of sea surface wind speed in the range of 4 to 24 m/s with an accuracy of 2 m/s or 101, whichever is greater. In addition, it will provide information of wind direction over 360 degrees with an accuracy of +/-20 degrees.

The science data gathered by the instrument are required for establishing input parameters for numerical weather forecast models, climate models and sea state forecasting. ASCAT will be used to determine wind vector fields at the sea surface level by measurement of the radar backscattering cross section sigma-0. The strength of the backscattered signals depends upon the amplitude and orientation of the surface capillary and small gravity waves, which in turn are related to the wind velocity.

The nominal ASCAT mode is designed to provide data products with a 50km resolution. An enhanced resolution mode (TBC), for use over land and coastal zones, will provide a resolution of 25km.

ASCAT is an FM/CW radar system. It operates in C-Band at 5.255 GHz using a long pulse with linear frequency modulation. ASCAT will measure the radar reflectivity of the sea surface over two 550 km wide swaths (position defined by an incidence angle of 25 deg) one on either side of the METOP-1 ground track. The doubling of the swath, relative to ERS-1, will improve spatial and temporal sampling. In each swath, a regular 25 km grid of points (nodes) is defined where the sigma-0 values are determined. The wind data extraction model which relates the backscatter coefficient sigma-0 to the wind speed and direction at each node relies on three independent measurements to ensure an unambiguous derived wind vector. The measurements are accomplished by consecutive operations of its fore, mid and aft antennas, covering three directions of view at 45 deg, 90 deg, and 135 deg relative to ground track respectively.

To convert the instrument measurement data to calibrated sigma-0 values, on ground corrections have to be performed. The ground processing takes into account both on-ground and the in-orbit characterisation.

In-orbit characterisation consists of noise measurements, plus internal and external calibration. The internal calibration compensates changes of instrument electronics. The external calibration includes the use of ground transponders to measure periodically the instrument gain. Instrument instabilities are corrected by use of an on-board calibration system.

A.5.4.2.1 Orbit and Attitude

Orbit and attitude requirements are defined in Section A.4.3. ASCAT shall be required to fully meet its performance requirements only in the reference orbit defined there.

A-5.4.2.2 Reference Operation Profile

The instrument shall be operated continuously over each full orbit.

A.S.4.2.3 Time Management

Datation and synchronisation of instrument data shall be in accordance with Section A.4.6.

A.5.4.2.4 General Operability

In accordance with Section A.4.4.

A.5.4.2.5 **Functional Requirements**

At instrument level the functions to be ensured include:

- detection and data acquisition of signals from the earth, and relevant calibration measurements. In particular, the instrument shall have an internal calibration facility which provides a continuous reference for instrument gain variation monitoring and related continuous corrections during data processing. This facility shall cover as far as possible of the whole instrument and signal path. The instrument shall provide a facility to measure the noise power content of the measurement data to allow a related correction for the noise power in the data processing.

- data flow packetisation and transmission to the Payload Data Handling sub-system of the spacecraft including datation;

- interfacing to the CCS of the spacecraft for the acquisition, scheduling, expansion and verification of the instrument telecommands as well as for the acquisition, monitoring, autonomous control and reporting of the instrument health and configuration status, as specified in Section A.4.4;

- power conversion an distribution for the ASCAT own equipment;

- thermal control;

- mechanical structure, mechanisms to satisfy the mission and the operational requirements.

A.5.4.2.6 **Operational Requirements**

The instrument shall be compatible with any satellite mode, all mission phases and shall function during routine mode changes of other instruments.

The instrument shall not obstruct the field of view of other instruments when in stowed configuration or during deployment or when operating.

Besides the nominal modes of operation, the following specific instrument support modes shall be considered and defined as necessary:

- launch mode with no or very limited power consumption;
- safe/survival modes ensuring the safeguard of the instrument when the satellite is not operating nominally;
- non-operation (stand-by) mode minimizing the power consumption when the instrument is not operating in its normal or calibration modes;
- back-up mode ensuring the safe instrument survival in case of severe instrument failures, e.g. failure in the instrument control unit;
- test mode ensuring the possibility to make the acquisition of processed data and of their raw data having bypassed the digital signal processor. This acquisition shall be possible for each selected antenna port;
- raw data mode for debugging during on-ground tests and in-orbit diagnostics.

Calibration modes shall be considered for the execution of the in-flight instrument calibration required to achieve the instrument performance.

For calibration with ground terminal transponder, in wind calibration mode, the receive channel shall insert a +540 kHz off-set.

A.5.4.2.7 **Design Requirements**

The instrument shall be designed in accordance with Section A-4.6 Section A.4.9, Section A.4 10 and Section A.4.11.

Auxiliary data necessary to interpret or use the observational data shall be contained in the science data stream.

A.f.4.2.8 **ASCAT Performance Requirements**

The performance requirements, shown in Table A.5.4.2.8-1 are valid over the entire reference orbit for all modes of operation, for the specified temperature range, and over the lifetime. For terms and definition used in Table A.5.4.2.8-1, see Annex H of the SOW.

Parameter	**Requirements**	**Remark**
Spatial Resolution	< 50 km	along and across track
Spectral Resolution	c 1/50 km-'	along and across track
Sampling	< 25 km	along and across track
Radiometric Resolution, Kp Crosswind (4 m/s.) Upwind (24 m/s)	 <theta-i/8 mid < 3% side < 3%	for all three beams near and far swath theta-i = incidence angle across full swath
Dynamic Range	see Table A.5.4.2.8-3	24 m/s upwind values increased by 3 dB
Interbeam Radiometric Stability	c 0.46 dB (TBC)	per beam
Radiometric Accuracy	≤ 0.57 dB (TBC)	
Aliasing	< 0.1%	
Ambiguities	c 1%	
Centre Frequency	5.2555 GHz +/- TBD	
Swath Length	Continuous	
Swath Width	2 * 500 km 2 • 550 km	full performance reduced performance
Localisation Accuracy	< 10 km	along and across track
Incidence angle for near cell mid-beam	25 deg	edge of swath
Polarisation	VV	
Cross-Polarisation	≥ 15 dB	one-way propagation
Power Demand	< 280 w (TBC)	operation
Mass	< 220 kg (TBC)	
Data Rate	< 60 kbps	TBC
Reliability	> 80 % (TBC)	5 years

Table A.5.4.2.8-1: ASCAT Performance Requirement

Modified performance requirements for the enhanced resolution mode for use over land, ice and in coastal regions, are provided in Table A.5.4.2.8-2. The validity of these is TBC.

Parameter	**Requirement**	**Remarks**
Spatial Resolution	< 25 km	along and across track
Spectral Resolution	< 1/25 km^{-1}	along and across track
Sampling	< 12.5 km	along and across track
Radiometric Resolution, Kp Crosswind (4 m/s) Upwind (24 m/s)	TBD	To be optimised with respect to the low-resolution design
Aliasing	TBD	
Abiguities	TBD	

Table A.5.2.8-2: ASCAT High Resolution Performance Requirement

For performance assessment, on-ground calibration and characterisation shall be taken into account. The backscattering coefficients are given in Table A.5.4.2.8-2.

Incidence Angle Sigma-0 (deg)	sigma-o (dB) Upwind 24 m/s	sigma-o (dB) Crosswind 4 m/s
25	+1.3	-9.6
30	-1.2	-12.7
35	-3.5	-16.3
40	-5.5	-19.4
45	-7.2	-22.1
50	-8.7	-24.4
55	-10.0	-26.2
60	-11.0	-27.6
65	-11.8	-28.6

Table A.5.2.8-3: Backscattering Coefficient

Parameter	Value
Atmospheric Attenuation (1-way)	0.01 dB/km signal path
Atmospheric Height	12.5 km
Rein attentuation (l-way)	0.094 dB/km signal path
Rain Depth	1 km

Table A-5.2.0-4: Atmospheric Parameters

A.6 AIT/AIV REQUIREMENTS

The AIV/AIT programme shall ensure that the design and performance requirements of the METOP satellite are met before launch. In the following definitions of the AIV/AIT programme the Contractor may propose, with justification and for agreement with the Agency, modifications to the requirements.

A.6.1 VERIFICATION REQUIREMENTS

The verification requirements shall be specified in a satellite verification plan.

The verification plan shall record in matrix form compliance with the design and performance requirements as defined in the METOP SOW and lower tier documents.

The method of verification shall be identified i.e. test, analysis or assessment as well as the level of integration when verification is performed i.e. equipment, instrument or sub-system, payload or platform and satellite level.

For requirements that can only be directly verified in orbit, indirect verification methods shall be utilised based on ground test with complementary analysis for in-orbit conditions.

The following definitions shall be used for test, analysis and assessment:

- **Test**: This method encompasses functional performance tests, environmental tests, measurements etc. to he performed following agreed and approved test procedures. Operational and/or environmental conditions shall be simulated to the extent possible.

- **Analysis**: This method evaluates available engineering data, or uses mathematical and/or simulation tools to verify the respective requirements.

- **Assessment**: This method includes review of design, inspection of hardware and proof for similarity of design.

Verification is for:

- Design qualification, i.e. demonstration that the design of the METOP satellite of its GSE and other items specified as part of the programme comply with adequate margin with the requirements;

- Acceptance of products generated in the programme, by demonstrating that hardware and software are free from workmanship errors and material faults, that they conform with the design baseline, and that they perform and function as required in the specified flight environment;

- Delivery of correct documentation.

A.6.2 MODEL PHILOSOHPY

The METOP satellite development shall distinguish between a satellite, platform and payload specific approach.

The METOP development concept shall utilise the following model definitions:

- Structural (Thermal) Model (STM)
- Engineering Model (EM)
- Proto-Flight Model/Flight Model (PM/FM)

A.6.2.1 **METOP Structural Thermal Models**

The structural model shall be used for mechanical qualification and shall as a minimum allow for the following:

- verification of structure mathematical model
- qualification of payload/platform mechanical design
- qualification of platform/payload mechanical interfaces
- alignment verification
- harness mechanical qualification.

The structural model shall be submitted to:

- static load and stiffness test
- modal survey test
- sinusoidal and random vibration test
- acoustic noise test
- any additional test required by the launch authority

The mechanical qualification of the satellite shall foresee vibration and acoustic testing of the coupled payload S(T)M and platform S(T)M at satellite level.

Modular verification at payload and platform level shall not be considered unless there are justified limitations of environmental test facilities.

The scope of the platform S(T)M and the qualification required shall be dependant on heritage.

Interface checks to the launch vehicle adapter as well as preliminary deployment, separation tests shall be envisaged either during the S(T)M or EM campaigns.

Thermal qualification at structural model level will be subject to the overall model philosophy and the platform heritage from SPOT/PPF. Adaptions from recurrent designs may be subject to dedicated thermal qualification tests.

The S(T)M shall be fitted with equipments/instruments dummies that are representative of flight units with respect to mechanical aspects and thermal aspects (TBD) and harness. Critical areas may require a higher level of definition, e.g. propulsion subsystem, antennae, mechanisms, specific instrument areas.

A.6.2.2 **METOP Engineering Models**

The engineering model shall be used for electrical design verification and specific pre-qualification activities.

At satellite level (pre)-qualification shall be performed in the following areas:

- EMC test
- RFC test

Electrical, operational and procedural interfaces (including hardware/software compatibility) between payload and platform shall be verified.

The necessity of a dedicated EM model for the service module (SVM) shall be considered in the light of SPOT/PPF heritage.

In that case a satellite level test, consisting of a PLM EM and SVM PFM (proto-flight model) configuration, is considered an acceptable approach. Early availability of the SVM PFM is a pre-requisite.

The PLM EM shall be used as a minimum for the verification of:

- integration sequence
- functional performance
- EMC test
- thermal vacuum/thermal balance test with limited performance verification under qualification level temperature extremes.

Solar simulation shall be the baseline for the payload module (PLM) thermal balance test.

Equipment/Instrument models shall be representative of flight units for mechanical, electrical and thermal interfaces.

As a baseline dedicated engineering/qualification models (EQM) shall be used. EEE parts used in EQM shall have as a minimum MIL temperature range.

The use of flight model units may be considered subject to Agency approval.

A.6.2.3 METOP Proto-Flight Model

The PFM satellite shall be subject to acceptance testing including as a minimum:

- sinusoidal vibration test
- acoustic noise test
- alignment verification
- EMC test
- full deployment tests

Compatibility tests of the flight software with the PFM satellite shall be performed as well as system validation with the METOP ground segment.

Thermal balance/thermal vacuum test on SVM and PLM modules separately shall be the preferred baseline.

An infrared simulation test at satellite level shall not be considered for METOP-1 (complexity, shadowing, view factors).

Solar simulation shall be the baseline for the payload module (PLM) thermal balance test.

The payload module PFM acceptance shall include:

- integration
- functional performance verification
- EMC tests
- thermal balance test
- thermal vacuum test for limited performance verification under acceptance level -temperature extremes.

The platform module PFM acceptance shall include:

- integration
- functional performance verification
- EMC tests
- thermal balance test
- thermal vacuum test for limited performance verification under acceptance level temperature extremes

Based on demonstration of PPF/SPOT heritage thermal balance testing may be deleted for the platform module.

Instrument/Equipment models shall be flight standard based on Hi-Rel EEE parts.

In principle flight spare units shall be available at the start of the METOP FM payload/platform and satellite AIV programme.

A.6.2.4 METOP Recurrent Flisht Models

Recurrent flight models shall follow the PFM approach and provided that similarity is maintained, the following deviations are permitted:

- deletion of thermal balance test
- workmanship vibration test limited to the launcher thrust axis
- de-scoping of EMC testing

A.6.2.5 **Equipment/Instrument Models**

For equipment/instrument models in principle the following baseline shall be maintained:

- 1 set SM models

- 1 set EM/QM models
- set FM/PFM models
- flight spare for unit type

A.6.3 INSTRUMENT TEST REQUIREMENTS

The AIT plan shall ensure that main elements of the instrument test procedures can be reused during the higher level payload and satellite tests.

Incoming inspection shall cover:

- verification of instrument ICD mechanical requirements as well as visual inspection for physical damage.
- electrical incoming inspection with instrument dedicated check-out equipment. Functional and electrical performance will be verified to the extent that is feasible in ambient conditions.

Instrument tests at payload and satellite level shall include an initial and final functional and electrical performance test at the beginning and completion of each environmental test.

Intermediate tests during payload thermal vacuum exposure shall verify correct performance of selected electrical and mechanical functions at temperature plateaus.

A full instrument end-to-end verification during payload thermal vacuum testing shall be subject of a feasibility study.

Instrument end-to-end verification at payload or satellite level shall be considered under ambient conditions.

Instrument electrical integration at payload level will require the following electrical integration tests:

- communication check
- short electrical performance test
- full electrical performance test.

A-6.3.1 Communication Check

The main purpose of this test is to prove that the instrument can be commanded via the satellite (CCS) bus and that proper telemetry response is given. No stimuli are required.

Power is provided via the payload power bus or via instrument EGSE.

A.6.3.1 Short Electrical Performance Test

The purpose of this test is to demonstrate that the instrument science data link functions.

The test shall be a subset of the full performance test and avoid manual or time consuming operations.

In principle the data link shall be verifiable without the need of external stimuli. Science data may be generated by instrument internal calibration modes if functional.

Instrument EGSE shall be capable of receiving instrument science data *via* dedicated payload EGSE.

A.6.3.3 Full Blmctrical Performance Test

The purpose of this test is to demonstrate the full electrical performance of the instrument in compliance with known stimuli.

Instrument EGSE will be required to provide stimuli to the instrument and to verify the received science data from dedicated payload EGSE.

Stimuli will be selected to provide adequate confirmation of correct instrument electrical performance.

The level of functional performance verification will depend on complexity of stimuli, operation of detectors, purging requirements etc.

The full electrical performance test is not intended to cover characterisation or calibration of the instrument.

A.6.4 OVERALL AIT REQUIREMENTS

All defined operational modes of hardware and software items shall be tested to the extent verifiable on-ground, including redundancies, cross-strapping and back-up, emergency modes.

Instruments shall be designed to be functionally self contained with minimal interfaces (mechanical, electrical, software, etc.) with the Payload Module so as to ensure they can be tested independently of the PM and to permit flexibility in the PM configuration.

At payload, platform and satellite levels an adequate selected set of performance tests shall be conducted.

Repeatability and reproducibility of tests shall be maintained throughout the AIT programme.

Commonality between operational procedures used during the AIT programme and those contained within the Flight Operations Manual shall be an objective.

Selected S-band data from satellite level shall be made available in annotated form to the Agency on computer compatible tapes (CCT) to assist to verify ground segment compatibility.

The data required to operate the satellite shall be organised in a common computerised data base structure for all levels of on-ground test.

This data base shall be able to support in-orbit operation, with the minimum of transportability of AIT TM and TC data, and shall at least be made available in a defined format on CCT for ground segment compatibility verification.

Interfaces to electrical check-out equipment shall be accessible at satellite, payload, platform and instrument level.

Mounting provisions shall be provided for test fixtures and non-flight items as required.

A.6.5 EGSE

EGSE and its associated software shall provide facilities for data reception and recording and for controlling and monitoring electrical, functional performance and environmental tests and related qualification/acceptance activities on all models and all levels of mission dependant assembly, integration and testing.

EGSE shall be based on commercially available computer systems. The operating system used shall have multi-tasking capability and adequate support for real time Operation. If a distributed system is implemented provisions for synchronisation to real time events shall be made. Software shall be written in a high level language. For time critical parts of the software, assembler language shall be used.

All EGSE computers at all levels shall be operated using a common check-out language (MMI). For critical operations, command input shall be definable at two stage operations. For output of essential information, a protected area (e.g. no overlaying windows) shall be provided.

It shall be possible to re-use check-out sequences and automatic test procedures (ATP), or parts thereof, written for use on EGSE at a lower level (equipment or instrument) at a higher level (integrated payload/satellite).

Test sequences of instrument commanding and instrument data evaluation in instrument automatic test procedures shall be separated to facilitate the re-usability of automatic test procedures.

Instrument EGSE shall comprise the following functions capable of operating throughout integration from instrument level up to satellite level:

- a means of commanding and monitoring the instrument;
- a means of providing the necessary stimuli to demonstrate satisfactory instrument performance;
- a means of extracting and analysing instrument science data.

EGSE shall provide a means of archiving and off-line post-test processing of satellite and instrument data.

As a baseline two sets of EGSE's shall be foreseen to support an EM and FM programme in parallel and for redundancy purposes.

The design life of the EGSE shall be 10 years.

A.6.6 SIMULATORS

Payload and Platform simulators, to verify the payload, platform and satellite EGSE set-ups, shall be developed dependent on the AIV concept and final architecture of the on-board data-handling system.

The design life of the simulators shall be 10 years.

A.6.7 MGSE

The MGSE shall comprise the non-standard mechanical equipment required to support the sub-systems and the instruments during assembly, integration, alignment, check-out, functional testing, environmental testing and transportation.

The satellite hardware shall provide interfaces to MGSE which are necessary for test, transportation and handling purposes.

A.7 SOFTWARE REQUIREMENTS

A.7.1 DESIGN REQUIREMENTS

A.7.1.1 RON Storage Limitation

On-board storage of software in ROM memories shall be limited such that software corrections/updates can be made when METOP is in orbit. All program code shall run from RAM, except for Safe Mode Code and the code needed for the loading of software from ROM to RAM.

A.7.1.2 Independence of Safe Mode Software

Any software utilised in the Safe Mode defined in this document shall be completely independent (design and verification) of all nominal safe mode software, and shall be protected from inadvertent modification.

A.7.1.3 Commonality

A.7.1.3.1 Software Languages

The METOP software shall be written in a standard high-level language and by using validated development tools.

A.7.1.3.2 Re-Use of Software

Software development and qualification tools shall support a possible re-use in the METOP Ground Segment.

A.7.1.3.3 Use of Commercial DBMS

Ground-based data bases shall be implemented on the basis of a commercially available and European-wide supported Data Base Management System (DBMS).

A.7.1.3.4 DBMS Requirements

DBMS packages shall include supporting procedures and application8 to unlock, recover and correct the data base in case of failures and errors in hardware, software, data links, power supply, or by operators.

A.7.1.3.5 Common Relational Database

Wherever a relational database is required a common relational DBMS shall be used, with the same interface language (query language).

A.7.1.3.6 Software Modulari ty

On-board software shall be modular in order to facilitate coet-effective development, integration and test activities, and in-orbit modifications.

A.7.1.3.7 Software Update8 In Orbit

Any S/W updates in orbit, via the uplink from ground, which are part of normal operatione, such a8 data and configuration table updates, MTL updates, payload instrument software updates, etc. shall be possible via macro-cormnande with METOP continuing to operate nominally. During any other S/W updates, e.g. for correction of errors, METOP shall continue operating nominally, or at least remain in a Payload *OFF Mode or* the Safe Mode providing all support features for payload instrument survival as specified in this document.

A.7.1.3.0 Replacement of Modules In Orbit

Software updates in orbit shall be possible as follows

- replacement of single modules;
- sequential replacement of single modules.

A.7.1.3.9 Software Tools and Procedures

METOP software shall be accompanied by a support software set of tools/procedures for generation, update, verification and replacement in the METOP software system, for use by the ground system operating METOP in flight. METOP software shall have configuration identification according to Annex B of the SOW, AD3.

A.7.1.3.10 Standards

All Platform software shall comply with the METOP Software Engineering Requirements, SY-16. In the meantime, as a guideline, AD35 shall be used.

A.7.1.3.11 Software Classification

All software shall be classified according to ESA-PSS-05-O (AD29).

A.7.2 FUNCTIONAL REQUIREMENTS

A.7.2.1 Software Support of Ground Testing

The METOP software shall be designed to support METOP testing on ground, without modification of this software except for data tables as required for ground testing.

A-7.2.2 Reconfiguration bv Software

METOP software shall reconfigure as necessary for all Platform and payload reconfiguration in orbit, based on requests from MTL, or directly from ground, with minimum interference to the operation of the active payload instruments.

A.7.2.3 Downlinking of Software Configuration

METOP shall permit downlinking of the current software configuration, on ground request.

A.7.2.4 Changing of Software from Ground

The METOP design shall not preclude that the software in any on-board location including core memories, excluding PROWS, can be changed from ground, at a sub-module level, and in individual memory locations, as a back-up.

A.7.3 MISSION PREPARATION AND SUPPORT SOFTWARE

A.7.3.1 Flight Operations of Support Software

The Flight Operations and support software shall include:

a) a METOP Satellite Reference Database (SRDB) containing all the required Flight Configuration Data. This SRDB shall be used as the single reference source of data to issue commands and process telemetry and for both on-board and EGSE software options.

b) Support software together with associated models and algorithms for on-board resources management.

A.7.3.2 Use of RDBMS for SRDB

The flight configuration SRDB shall be set up as relational database.

A.7.3.3 Inclusion of Payload Data

The database shall be designed to allow for inclusion of payload data to accommodate the full mission configuration.

A.7.4 SOFTWARE DEVELOPMENT ENVIRONMENT

A.7.4.1 Use of SDB

A standard Software Development Environment (SDE) shall be used for the development and maintenance of all METOP software.

A.7.4.2 SDB Capabilities

The SDE shall provide the capability to generate, configure and maintain all executable on-board and EGSE software and data tables required for the operation of flight configurations and ground support equipment.

A.7.4.3 SDE Support Software

Support software shall be provided for testing of the generated executable software and data tables.

A.7.4.4 SDB Environments

The software shall execute in a commercially available and supported environment consistent with the flight schedule of METOP.

A.7.5 SOFTWARE SAFETY

Hardware failure tolerance shall *not be* jeopardised by the software design. Software faults or failures shall not result in hazardous hardware operation. Hardware failures shall not result in software executing hazardous operations.

For safety critical software, any interface to non-safety critical software requires specific verification and validation, as well as plausibility checks during operations. Any software used for this verification and validation process, as well as for the plausibility checks, has to be classified critical as well. Relevant test software shall be classified at the same level. Safety critical software shall be protected from inadvertent operation and modification.

Class A software shall be subjected to independent software verification and validation.

A.7.6 SOFTWARE RELIABILITY

Reliability of the METOP software must be such that the specified reliability requirements of the relevant systems, subsystems and instruments are achieved.

A.0 PRODUCT ASSURANCE REQUIREMENTS

A.8.1 PRODUCT ASSURANCE PROGRAMME REQUIREMENTS

The METOP-1 programme basic PA requirements are defined in Annex B of the sow, Product Assurance Requirements. In addition to PA related requirements expressed elsewhere in this present specification, the following additional requirements apply.

A.B.2 RELIABILITY REQUIREMENTS

A.8.2.1 Failure Tolerance Requirements

A.8.2.1.1 Single Failure

No single failure shall lead to catastrophic or serious consequence. Refer Product Assurance Requirements Annex B for definition of severity consequence categories.

A.8.2.1.2 Operator Error8

No single operator error shall lead to catastrophic or serious consequence.

A.8.2.1.3 Combination of Error with Failure

No combination of a single failure and a human operational error shall lead to catastrophic consequence.

A.8.2.2 Failure Propagation

One failure in one item function shall not cause failure or degradation of another function of the same item or of an interfacing item.

A.8.3 SAFETY REQUIREMENTS

The technical safety requirements of the CSG safety regulation, AD27, together with the following requirements are applicable. PSS-01-402 should be used as a source of additional technical safety requirements as appropriate.

A.8.3.1 Emergency, Caution, Warning and Saflnq

Caution, warning and Safing devices are required in the ground processing configurations of the S/C and related GSE, for hazards with consequences catastrophic or serious.

A.0.3.2 Propellants

A.8.3.2.1 Flow Control Devices

Opening of any flow control device shall not lead to adiabatic detonation or uncontrolled release of fluids.

A.0.3.2.2 Flow Shut-off Devices

Flow shut-off devices shall be incorporated at the outlet of each propellant tank pair.

A.8.3.3 Pyrotechnic Devices and Functions

The requirement of MIL-STD-1576, AD28 are applicable to all pyrotechnic devices and functions with hazardous failure modes.

The following changes to this standard apply:

- paragraph 6.10.c and the RF impedance and RF sensitivity tests in Table II are not applicable;
- the reference test methods are 2204, 2207, 2208, 2208.1 and 4303;
- for applications using the NASA Standard Initiator (NSI), Tables I, II, III, IIIA, IV, IVA and V are not applicable, and the reference test methods are 1102, 1103, 1111, 1404, 2203, 2205, 3113, 3114, 3401, 3403, 3407, 4308 and 4309.

A.0.3.4 **Batteries**

A-0.3.4.1 **Batteries Pressure Vessel Requirements**

All specified pressure vessel requirements are applicable to any cell/battery whose failure may result in serious or catastrophic hazard consequences.

A.8.3.4.2 **Batteries - Released** 'Product.

Battery design shall protect the surrounding environment from the release of electrolyte or other battery vent products.

A.8.3.5 Ground **Support Equipment**

Ground Support Equipment (GSE) shall be designed such that its operation does not result in the creation of hazardous conditions which may have serious or catastrophic consequences. The appropriate failure tolerance requirements are applicable to the GSE design in all its operating configurations.

A.8.4 **MAINTAINABILITY REQUIREMENTS**

A.8.4.1 Instruments Maintenance

It shall be possible to repair, remove or replace each of the instruments, should they require maintenance, repair or modification, with minimum disturbance to and interference with the platform or the other instruments.

A.8.4.2 Accessibility before Launch

Items *requiring* integration, for safety, logistic or life reasons, close to launch, e.g. pyrotechnics and items which may require adjustment, servicing or maintenance before launch shall be accessible without removing any equipment or instrument.

A.8.4.3 **Fuses and Pyros**

Where fuses or pyros are used they shall be accessible from the outside of the unit without major intervention being required for their replacement.

A.8.5 **COMPONENT SELECTION, PROCUREMENT AND CONTROL REQUIREMENTS**

A.8.5.1 De-rating

Electrical and electronic components shall be derated in accordance with Annex B of the SOW, AD3.

A.8.5.2 Hybrid Circuits

Hybrid circuits shall meet the requirements of Annex B of the sow, AD3.

A.8.5.3 Mounting and installation of EEE Parts

The requirements of Annex B of the SOW, AD3, apply for installation and mounting.

A.8.5.4 Radiation

With respect to radiation effects, selected components will have a demonstrated susceptibility of 3 times the expected doses for lots subjected to radiation verification testing (RVT) or 5 times the expected dose for types not subject to lot testing but evaluation by radiation evaluation test (RET).

Parametric variations of the devices under the expected dosage shall be taken into account in the design/application.

With respect to cosmic radiation, devices which are known or proven to be susceptible to latch-up shall not be used.

Single event upset rates shall be specified such that overall satellite resulting non-availability meets the requirements of Section A.3.5, and the science data specified bit error rates are not degraded.

SEUs shall not cause permanent failure or degradation either directly or as a consequence.

A.8.5.5 Connectors (Electrical)

For interfacing with GSE during ground testing, all flight connectors shall be provided with connector savers.

The requirements in Annex B of the SOW, AD3, apply for the soldering or crimping of connector contacts.

Tethered metal connector caps shall be provided for all unused connectors on flight hardware which remain unconnected during the mission.

A.8.5.6 Quality Levels for EEE Components

EEE components used in the following items shall meet testing level B (level C for passive components with the exception of crystals, filters, cermet-fuses, relays and switches which shall be level B) of the appropriate ESA/SCC specifications:

- all Contractor procured flight hardware, including flight spares;
- all qualification hardware am required to achieve the verification objectives, where this hardware is destined for use as flight spares;
- for other qualification hardware (e.g. EM for certain qualification aspects) full temperature range MIL parts of appropriate standard shall be used.

A.8.6 MATERIALS, MECHANICAL PARTS AND PROCESSES REQUIREMENTS

A.8.6.1 Materials Selection Criteria

Materials used in the design shall be selected by considering the operational requirements for the particular application, and the properties of the candidate materials. The consideration of operational requirements shall include, but not be limited to, load distribution and magnitude, operational temperature, exposure environment, contamination and life expectancy. Attention shall be on mechanical strength properties, fatigue, thermal stability (creep and stress rupture), fracture toughness, crack growth rate, stress corrosion behaviour, outgassing, corrosion, material compatibility and cleanliness requirements. The use of magnetic materials shall be minimi-ed as far as possible.

A.8.6.2 Vacuum Stability and Outgassing

Materials used in the design and construction of hardware which will be exposed to the space vacuum environment shall have low outgassing properties. ESA test specification PSS-01-702 test method A is applicable, as identified in Annex B of the SOW, AD3.

Materials used in the design and construction of hardware which will be exposed to the space vacuum environment shall be resistant to degradation in that environment. Refer to Annex B of the SOW, AD3, for the procedure to evaluate materials for degradation. For each material to be tested, the detailed test procedure and accept/reject criteria shall be specified.

A.8.6.3 Ultraviolet Stabilitv and Radiation

Materials which are sensitive to UV light and/or radiation to which they will be exposed in a space environment, must not be used or they must be protected in order to minimise or eliminate radiation stresses. Refer to Annex B of the SOW, AD3, for the procedure to evaluate W-stability and radiation resistance as appropriate.

A.8.6.4 Stress Corrosion

A-8.6.4.1 Stress Corrosion - Selection of Materials

Refer to PSS-01-736 (identified in Annex B of the SOW, AD3) Table I to select metallic materials for structural applications; materials from Tables II and III shall not be used in structural applications. Refer to PSS-01-737(identified in Annex B of the SOW, AD3) for the test procedure if the stress corrosion properties of a material are not known.

A.8.6.4.2 Str666 Corrosion - Fluid Compatibility

The fluid compatibility and resistance of the proposed materials to stress corrosion under all expected exposure conditions shall be demonstrated by test data.

A-8.6.5 Atomic Oxygen Effect6

Materials exposed to space shall withstand attack by the residual atomic oxygen environment defined in Section A.4.8.11 or shall be protected accordingly.

A-8.6.6 Corroaion Prevention

A.8.6.6.1 **Dissimilar Metals**

Materials must be compatible or suitably protected. Refer to Annex B of the SOW, AD3, for compatibility specification. Material combinations must be selected in a manner to assure compatibility and/or minimize the potential for galvanic corrosion. When material combinations which are not compatible according to the table on page 35 of PSS-01-701 must be incorporated into the design, refer to MSFC-SPEC-250, RD20, for guidance on interface protection. Material combinations with a difference in EMF of greater than 0.5 V, in a clean atmosphere and with no satisfactory protective finish, shall not be used.

A.8.6.6.2 **Use** of Corrosion Resistant Materials

Resistance to corrosion, if risked through the use or storage environment of the concerned item, must be achieved by selection of corrosion resistant materials or application of suitable surface finishes. Refer to MSFC-SPEC-250, RD20, for guidance on surface finishes for corrosion protection. The preferred finish for aluminium, titanium and their alloys is anodizing. Paasivation is preferred for stainless steels and inconel.

A.8.6.6.3 **GSE Corrosive Resistance**

Specific requirements shall be derived for GSE in line with expected environment.

A-8.6.7 Radioactive Materials

The use of radioactive materials shall be avoided if possible. For application involving the use of radioactive material, a waiver request shall be submitted.

A.8.6.8 **Moisture Resistance**

Materials shall be moisture resistant, or shall be suitably protected to prevent deterioration due to moisture influence. Refer to MSFC-SPEC-250, RD20, for guidance on surface treatment.

This applies as appropriate for the specified ground storage and ground processing periods of the satellite and its GSE.

A.8.6.9 **Life**

Materials, after having been formed, shaped, treated according to design requirements, shall exhibit life and degradation characteristics compatible with the specified life time requirements.

A-8.6.10 Restricted and Prohibitad **Materials**

A-8.6.10.1 Use of Beryllium

Any application of Beryllium Oxide shall be identified to ESA.

A.8.6.10.2 Prohibited Materials

Use of the following materials is prohibited:

- plating of zinc and cadmium, exposed to the environment;
- mercury (liquid or gaseous);
- polyvinylchloride.

A.8.6.11 Resistance to Microbial Growth

Materials shall be resistant to microbial growth, or shall be suitably protected to prevent microbial growth. This applies as appropriate for the specified ground storage and ground processing periods of METOP-1.

A.8.6.12 Mechanical Parts

A.8.6.12.1 Suitability of Mechanical Parts

Mechanical parts shall be selected according to their technical suitability, their ability to withstand expected stresses and their ability to meet the safety requirements, and shall be of such quality to satisfy the criticality of their application.

A.8.6.12.2 Combination of Mechanical Part8

Where combinations of mechanical parts must be used (such as bolt/nut, bolt/washer/nut, bolt/washer/nut with lubrication etc.) only combinations which have proven (by testing performed) suitability of combination and performance within the anticipated service environment.

A.8.6.12.3 Processes

The processes used in the production of hardware shall in no way degrade the technical, quality, reliability and performance characteristics. The identified ESA process specification shall be performed according to Annex B of the SOW, AD3.

A.8.7 CLEANLINESS AND CONTAMINATION CONTROL

A.8.7.1 Contamination

Contamination shall be limited, by employing low contamination materials, and low contaminant monopropellant propulsion, and by shielding all payload instruments and its own sensitive surfaces from any direct and reflected thruster plume impingement, both from its own thrusters and launch vehicle thrusters. Materials generating deposits on sensitive optical and radiator surfaces of payload instruments shall be avoided in the design.

A.8.7.2 Microbial Contamination

The METOP-1 and its GSE shall be arranged such that transfer and distribution of particulate contaminants and micro-organisms on ground is effectively limited.

A.8.7.3 **Elimination of Contamination**

Areas where chemical and microbiological contaminants can settle and accumulate on ground shall be eliminated by design. If elimination is not possible due to justified design constraints, such areas shall be designea for easy access for cleaning.

A.0.7.4 **Visible Cleanliness**

The METOP-1 and its GSE shall be visibly clean as per AD3, 300 ppm obscuration factor.

A.8.7.5 **AIT Environments**

All Assembly, Integration and Test activities involving flight hardware shall be performed in an environment with a minimum cleanliness level of 100,000 as defined in AD3. Where this cleanliness level would impair the operation of mechanism or other equipment, or reduce the accuracy, resolution or performance of the instruments, the Contractor shall establish and provide the required minimum cleanliness level for the processes or operations involved.

A.9 OPTIONS

A.9.1 OPTION 1: EMBARKATION OF A DRS TERMINAL

The PDHS will provide a global data dump via DRS at Ka-Band. A complete data dump every orbit, achieved with an uninterrupted transmission, shall be feasible for a configuration with two DRS satellites. This capability has to be considered for demonstration on occasional basis. This implies that the design of the Ka-Band subsystem will be such that the impact on the satellite and on the other subsystems is minimised.

The PDHS will be able to dump data via DRS satellite(s) whenever the relative position of the DRS and the METOP satellites allows geometric visibility. For thermal and operational reasons a maximum duration of 20 min of dump time per orbit shall be assumed in the design. Switch over from one satellite to the other will take less than 5 minutes, from the moment when the satellite interrupts the data transmission, until it resumes emission into the correct direction of the new satellite.

It is not required to operate the link during X-Band data dump.

A.9.1.1 Link Requirements

The PDHS subsystem shall insure Global Data dump to ground station via DRS with the required quality over distances from the satellite up to 45500 Km.

- carrier frequency: 26.6 GHz TBC;
- data rate: 50 Mbit/s;
- modulation: BPSK or QPSK;
- coding: R-S or R-S concatenated with Viterbi (7, 1/2);
- EIRP: compatible with link budget;
- data quality: frame loss probability (Flp) better than 10^-6;
- modulation imperfections: according to AD37;
- dumping operations during lifetime: the subsystem shall be designed to operate once per orbit;

A.9.2 OPTION 2: RE-EMBARKATION OF S&R, SEM

In this option the CFI S&R and SEM will be embarked on METOP.

The requirements of A.5.2 apply.

All other requirements of this specification are maintained.

A.9.3 OPTION 3: EMBARKATION OF A GPS RECEIVER

METOP shall be capable of embarking a Global Positioning System (GPS) receiver in support of satellite attitude monitoring and orbit determination, both sets of data being transmitted for use on ground.

Use of GPS data for satellite attitude control is not required in the baseline system. However, a design case shall be assessed such that the AOCS can obtain its attitude mispointing estimates from the GPS. Such an interface and operating mode would only be invoked following the failure of the conventional AOCS sensor hardware, as a back-up mode.

Redundancy of the GPS is required (TBC).

A.9.3.1 GPS Performances

The GPS option is intended to provide a significant improvement to the real-time orbital position knowledge of METOP.

A-9.3.1.1 Orbit Position Accuracy

The GPS system shall provide a real-time geocentric position, with a reference to WGS84 geodetic coordinates. The real-time position error estimates shall be better than:

- Along-Track: 25m;
- Across-Track: 25m;
- Radial: 25m;

A.9.3.1.2 Attitude Knowledge Accuracy

The GPS system shall provide real-time attitude estimates with uncertainties equal to or better than the knowledge requirements specified in Section A.4.3.2.5.2.

Error compilation shall follow the rules given in Annex H.

A.9.4 OPTION 4: EXTENDED DATA DUMP CAPABILITY IN X-RAND

The likely introduction of new or improved sensors in future METOP satellites, which might provide a greater information flow, requires to consider an increased storage and a higher rate data dump capability.

A-9.4.1 Extended Data Storage

The on board storage Sub-system shall be able to store two full orbit of the Global Data Stream.

It shall retain a simultaneous and independent read and write capability. It shall be able to sustain an output data rate that allows a complete data dump during the ground station visibility.

A-9.4.2 Extended Global Data Dump to Ground (X-Band)

The PDHS subsystem shall insure Global Data dump to ground stations with the required quality when the satellite elevation with respect to the ground station is greater than 5 deg. Link attenuation due to atmospheric factors (i.e. rain, clouds, scintillation, etc.) not exceeded for 99.92 of time shall be taken into account.

- slant range: up to 3000 km;
- carrier frequency: 7.8 GHz;
- permitted bandwidth: 7.750 - 7.900 GHz TBC;

- data rate: 100 Mbit/sec (TBCO);
- modulation: QPSK or DEQPSK;
- coding: TBD; compatible with data quality requirement and bandwidth;
- EIRP: such to generate an almost constant flux at ground stations; to be optimised taking into account coding and bit rate;
- Ground Station G/T: 32 dB/K at 5 deg elevation;
- data quality: frame loss probability (Flp) better than 10^-6;
- on board technological loss: less than 1 dB.

A.9.5 OPTION 5: SATELLITE SIMULATOR

A satellite simulator shall be developed for testing and operator training in support of in-orbit operations. The facility shall operate with actual flight software.

STATEMENT OF WORK AND TECHNICAL REQUIREMENTS

ANNEX B

PRODUCT ASSURANCE REQUIREMENTS

Prepared by : METOP Team

Approved by: A. Soons

Head, Product Assurance and Safety Department

Approved by: P.G. Edwards 29/9/94

METOP Project Manager
Earth Observation Projects Department

Table of Contents

B1. INTRODUCTION

B1.1 PURPOSE

The purpose of this document is to provide the Product Assurance requirement8 applicable to the METOP-1 project.

This document establishes the basic requirements for an integrated Product Assurance system for all Contractors participating to the METOP-1 project.

The requirements of this document pertain to all PA disciplines i.e. reliability, safety, parts/materials/processes, software PA, quality assurance, configuration management.

81.2 APPLICABILITY

The requirements of this document shall apply to the phase B of the METOP-1 project. Some requirements which are only applicable to next project phases have been incorporated and identified as such, in order to get prepared for these phases.

It is the responsibility of the prime Contractor to ensure the proper implementation of these requirements on the sub-Contractors, or suppliers.

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B2. APPLICABLE AND REFERENCE DOCUMENTS

82.1 APPLICABLE DOCUMENTS

PSS-01-0 Issue 2 Draft 6.1 (June 1990)
Basic requirements for product assurance of ESA spacecraft and associated equipment.

PSS-01-11 Issue 1 (March 1989)
Configuration management and control for ESA space systems

PSS-01-20 Issue 2 (February 1991)
Quality assurance requirements for ESA space systems

PSS-01-21 Issue 2 (April 1991)
Software product assurance requirements for ESA space system8

PSS-01-30 Issue 2 (March 1992)
Reliability assurance requirements for ESA space systems

PSS-01-40 Issue 2 (September 1988)
System safety requirements for ESA space systems and associated equipment

PSS-01-60 Issue 2 (November 1988)
Components selection, procurement and control for ESA space systems

PSS-01-70 Issue 4 (January 1994)
Materials and process selection and quality control for ESA space systems and associated equipment

PSS-01-201 Issue 1 (August 1983)
Contamination and cleanliness control

PSS-01-202 Issue 1 (June 1983)
Preservation, storage, handling and transportation of ESA spacecraft hardware

PSS-01-203 Issue 1 (August 1983)
Quality assurance of test houses for ESA spacecraft and associated equipment

PSS-01-204 Issue 1 (September 1984)
Particulate contamination control in clean rooms by particle fall-out measurement

PSS-01-301 Issue 2 (April 1992)
Derating requirements and application rules for electronic components

PSS-01-401 Issue 1 (March 1989)
ESA fracture control requirements

PSS-01-605 Issue 1 (May 1990)
Capability approval programme for hermetic thin-film hybrid micro-circuits

PSS-01-606 Issue 1 (July 1986)
The capability approval programme for hermetic thick-film hybrid micro-circuit8

PSS-01-608 Issue 2 (April 1987)
Generic specification for hybrid micro-circuit8

PSS-01-700 Issue 2 (August 1993)
The technical reporting and approval procedure for material8 and processes

PSS-01-702 Issue 1 (March 1983)
A thermal vacuum test for the screening of space materials

PSS-01-704 Issue 1 (August 1982)
A thermal cycling test for the screening of space materials and processes

PSS-01-705 Issue 1 (October 1982)
The detection of organic contamination of surfaces by infrared spectroscopy

PSS-01-706 Issue 1 (March 1983)
The particle and ultraviolet (UV) radiation testing of space materials

PSS-01-707 Issue 1 (February 1984)
The evaluation and approval of automatic machine wave soldering for ESA spacecraft hardware

PSS-01-708 Issue 1 (March 1985)
The manual soldering of high reliability electrical connections

PSS-01-709 Issue 1 (July 1984)
Measurements of thenno-optical properties of thermo-control materials

PSS-01-710 Issue 1 (October 1985)
The qualification and procurement of two sided printed circuit boards (gold plated or tin/lead finished)

PSS-01-711 Issue 1 (October 1982)
Product assurance requirements for Micro VCM apparatus and associated equipment.

PSS-01-713 Issue 1 (October 1982)
Measurement of the peel and pull-off strength ofcoatingsand finishes with pressure sensitive tape

PSS-01-718 Issue 1 (October 1987)
The preparation, assembly and mounting of RF coaxial cables

PSS-01-720 Issue 1 (July 1985)
Determination of the susceptibility of silver-plated copper wire/cable to "red plague" corrosion

PSS-01-722 Issue 2 (December 1990)
The control of limited life items

PSS-01-726 Issue 2 (December 1990)
The crimping of high reliability electrical connections

PSS-01-728 Issue 2 (February 1991)
The repair and modification of printed circuit boards and soldered joints for space use

PSS-01-730 Issue 1 (March 91)
The wire wrapping of high reliability electrical connections

PSS-01-736 Issue 1 (May 1981)
Material selection for controlling stress-corrosion cracking

PSS-01-737 Issue 1 (September 1981)
Determination of the susceptibility of metals to stress corrosion cracking

PSS-01-738 Issue 1 (March 1991)
High-reliability soldering for surface-mount and mixed technology printed circuit boards.

PSS-01-748 Issue 1 (March 1992)
Requirements for ESA approved ekille training and certification (Electronic assembly techniques)

PSS-05-0 Issue 2 (February 1991)
ESA software engineering standards

ESA/SCC System

ESA/SCC QPL

CSG-RS-lOA-Ct?
Edition 4, Revision 0 (August 1991)
CSG Safety Regulations

MIL-EDBK-217F + *notice 1*
Reliability prediction for electronic equipment

MIL-STD-454K
Standard general requirements for electronic equipment

82.2 **REFERENCE DOCUMENTS**

The reference documents given in the following list are for general guidance only. They need not be applied but they should be given preference over other documents covering similar topics.

PSS-01-402 Issue 1, draft 3 (May 1990)
Design safety requirements for ESA space systems

PSS-01-603 Issue 2 (June 1985)
ESA preferred parts list

NPRD- 91
Non electronic parts reliability data 1991

ISO-9004.7
Guidelines for Configuration Management

PSS-01.302 Issue 1 Draft 4
Failure rates for ESA Space Systems

PSS-01-701 Issue 1, Rev. 3 January 1994
Data for the *selection of* space materials

QC/172/RdM Iss.1, June 1992
ESA ASIC Design and Assurance Requirements.

B2.3 ORDER OF **PRECEDENCE**

In case of conflict between documents applicable to the METOP-1 project, the order of precedence shall be as follows :

1. The Contract
2. This Statement of Work including Annexes
3. Other Applicable Documents.

B3. PRODUCT ASSURANCE MANAGEMENT

83.1 PRODUCT ASSURANCE POLICY

The ESA Product Assurance policy is contained in PSS-01-O.

83.2 ORGANISATION

The Contractors shall establish and maintain a Product Assurance organization for the project.

The Product Assurance organization shall comprise all personnel, resources, and facilities necessary to accomplish project Product Assurance activities effectively, economically, and on-time.

The PA organization for the project shall be directed by a PA manager.

The PA manager shall be part of the company PA organization.

The PA manager shall, for the day by day project activities, report directly to the project manager and be responsible for the proper conduct and conclusion of the overall PA programme.

The Contractor shall ensure that the appointed PA manager has the requisite seniority and authority and that the organizational links and resources exist to permit his:

- unimpeded access to higher management;
- access to the support of other Contractor organizational groups or resources either planned or required for emergency investigations;
- direct access to his counterparts at ESA and subcontractors.

The PA organization shall provide for, and promote exchange of information among the PA disciplines and between the PA and other project groups.

Responsibility for configuration management can be assigned to a configuration manager who is not a member of the Contractor PA organization although configuration management is part of PA in accordance with PSS-01-O.

83.3 PA PROGRAMME PLAN

B3.3.1 General

In response to the requirements of this specification, a PA Programme Plan shall be generated and maintained to document and control all PA activities.

The PA Programme Plan shall include details as to how the Contractor intends to verify that the programme will be accomplished and how he intends to perform supervisory and monitoring actions on subcontractors and suppliers.

Contractor internal company procedures may be referenced in the PA plan. Contractors should be aware that referencing internal company procedures in the PA plan will limit the company's ability to unilaterally change the procedures. All modifications to these procedures shall be considered as modifications to the PA plan.

The Product Assurance Programme Plan shall serve as a master planning and control document for the product assurance programme.

The Prime Contractor PA Programme Plan shall be approved by ESA.

Lower level Contractor8 PA Programme Plan8 shall be approved by the next-higher management level.
Each PA plan shall be applicable following its approval

Sub-Contractors PA Programme! Plan8 shall be forwarded to ESA for information.

In the event of a conflict between this specification and the approved PA plans, this specification shall take precedence.

Each PA plan shall include a section tcetifying to the plan' s compliance with the requirements of this specification and identifying any relevant discrepancies (compliance matrix).

Changes to the PA plan shall be submitted to customer's approval and shall be processed in accordance with the documentationmanagement requirements.

B3.3.2 Content

The plan shall describe the following items:

- Product Assurance Organization: the organizational structure established for the project's product assurance programme shall be described, including the interfaces with supporting groups, services and facilities. The product assurance manager and senior personnel of the product assurance group shall be named and their authority, responsibilities and position within the technical management structure established for the project clearly stated. Organigrammes, charts and exhibit8 describing organization elements and system flow shall be included. A statement of the manpower complement needed for the performance of the product assurance programme shall be included, showing the manpower required per time period/project phase.

- Tasks and Schedule: the PA tasks to be undertaken shall be described together with the relationship of these tasks to the overall programme milestones. The relationship of activities in each PA discipline to those of all other PA disciplines shall also be defined. This information Bhould be presented in a chart or graphical form.

- Deliverables: the PA documents to be delivered by the Contractors shall be identified with reference to the Documents Requirement List (DRL).

- Documentation: definition or *reference* to the product assurance design rules, standards, practices, method8 (including R & S analyses), procedures, and data formats that shall be used in the implementation and execution of each PA discipline. Detail8 shall be provided of any lists, specifications, reports and records which are to be prepared and maintained.

- Reporting : This section shall define the system used to report activity Btatus, progress and problem areas for the programme. This section shall also identify the specific form8 and procedures to be used for reporting.

- Quality Assurance Programme Plan.

- EEE Component Procurement and Control Plan.

- Part8 (non-EEE), Materials and Process Selection and Control Plan.

- Software Product Assurance Plan.

- Reliability and Safmty Assurance Plan.

- Critical Items Control Plan: this plan shall provide the control system for all reliability, and safety (including fracture critical) critical items.

- configuration Management Plan: as described in the statement of work. This plan can be delivered outside the PA plan.

B3.4 PA STATUS RXPORTS

Before each project progress meeting, the Contractor shall prepare and submit reports on the status of the product assurance program to ESA. The information in each report shall be related to information provided in previous reports. This report may be provided as a section in an overall project status report. The report shall as a minimum contain the following information

- Accomplishments: the report shall identify specific work activities, audits, inspections, visits and/or tasks which have been completed. This shall be done for both planned and unplanned items which serve to meet the requirements of the PA programme. The outputs and results of each item shall be specifically identified. This section shall contain a summary of significant decisions or actions affecting the product assurance programme.

- Work in Procress: the report shall identify specific work activities, activities and/or tasks which have been started but not yet completed. It shall identify the technical progress of each item with reference to the approved PA Programme Plan.

- Work Overdue: the report shall identify specific work activities, audits,events, inspections, visits and/or tasks which were planned or scheduled to occur-but did not take place. This shall include reporting work in progress which did not accomplish the objectives stated in approved plans, previous status reports, or other documents. For each item identified in this section solutions shall be identified with specific measures of progress and milestones.

- Status of critical items (for phase C/D): the report shall identify the status of all items identified in the Critical Items List. This shall include reporting the progress of reducing the criticality of specific items.

- Status of major non-conformances (for phase C/D): the report shall identify the status of all major non-conformances identified on the programme. This shall include the identification, consequential effects, planned activities for problem resolution, and resolution status of each non-conformance. This may be done by reference to existing reports which contain this information.

- Status of Problems: the report shall identify the status of all technical and/or management problems not controlled by a Non-conformance Report. This shall include identifying the nature of the problem, its consequential effects, actions taken or planned to resolve the problem, and the status of those actions. Reasons for unresolved problems continuing to exist should be identified.

- Status of EEE parts procurement activities.

- Future Activities: the report shall identify all planned activities, actions, and events for the forthcoming period. This shall include a schedule for all items.

83.5 PA PROGRESS MEETINGS

PA progress meeting8 shall be held between ESA and the prime Contractors and/or direct Contractors, these can be organised in the framework of the overall project progress meetings.

Special-purpose meetings may also be organized, as necessary, for various specialists (R & S, parts, processes, materials, software, etc.).

ESA may attend PA progress meetings organized at any level below the Prime Contractor level.

The minutes shall be written by the Contractor during the meeting, co-signed by both parties and circulated by the Contractor.

83.6 INTERFACES WITH CONFIGURATION MANAGEMENT

The configuration management requirements are defined in the PSS-01-11. The purpose of this section is to define the PA involvement in configuration management.

Product Assurance plays a three-fold role in configuration management involving:

- review of the design documentation,
- participation to the Configuration Control Board (CCB),
- identification and reconciliation of discrepancies between *as designed" configuration and "as-built' configuration (for phase C/D).

Any discrepancy observed between the *as designed" configuration and the "as-built" configuration shall be subject to the non-conformance processing procedure as defined in PSS-01-20.

B3.7 CRITICAL FUNCTIONS AND ITEMS CONTROL

The Contractor shall establish and maintain an integrated Critical Items Control Programme. Elements regarded as critical to the safety and reliability shall be formally identified and controlled as project critical items. The critical items shall include the Fracture Critical Items.

All items designated critical items, shall be subjected to special controls as follows:

- Critical items shall be uniquely identified and classified according to the nature of the criticality, and recorded in the project Critical Items List, which is subject to ESA approval.

- Critical items shall constantly be subjected to efforts to eliminate them or to reduce their criticality to acceptable levels, and, shall be regularly reviewed as regards their continued criticality.

- The Critical Item List including the criticality status of every Item shall be made available to the appropriate project personnel of the Contractors and their subContractors.

- The Critical Items List and the status of every critical items shall be included in regular status reports (for phase C/D).

- All design, manufacturing, and testing documentation which is related to critical items shall be identified and marked, and document traceability shall be maintained by document number and issue (for phase C/D).

- Appropriate and adequate representation is provided for Audits, Mandatory and Key Inspections, Material Review Boards (MRB), Configuration Control Boards (CCB), and Test/Qualification Review Boards which involve critical items (for phase C/D).

- Manufacturing, assembly, maintenance, servicing, testing, and operation involving critical items is monitored for problems which may affect the performance of the items during the Operational Phase (for phase C/D).

- Safety Critical Functions shall be qualified in accordance with the requirements of PSS-01-40.

Critical items shall be ranked for criticality using criteria which shall be established by the Prime Contractor and approved by ESA. The ranking shall be used to define the priority and extent to which critical items control procedures and measures shall be applied to each critical item.
The Critical Items List shall include all those items of hardware or software, and procedures, which are identified as critical in accordance with the requirements specified herein.
The critical items shall be reviewed during project reviews and closed during phase C/D project reviews.

B3.8 AUDITS

The Contractor shall conduct audits of his own (internal audits) and of his subContractor's and supplier's (external audits) facilities , equipment, personnel procedures, services and operations to verify the compliance with the PA requirements.

Each audit shall be performed by a team of Contractor personnel familiar with all written documentation applicable to the operation of the work areas being audited. It shall include examination of all operations and documentation, evaluation of actual operation as compared with established requirements, and terminate with recommendations for corrective and preventive actions and follow-up to assess results of recommendations.

The Contractor shall establish and maintain an audit plan designating the SubContractors and Suppliers to be audited, the current status and the schedule for auditing.

In addition to the planned audits, extra audits shall be performed when necessary to overcome failure, consistent poor quality, or other problems.

ESA reserves the right to be represented in the audits. For this purpose, the audit schedule shall be supplied to ESA and up&ted regularly. No audit shall be performed without giving ESA at least 5 working day notice.

ESA reserves also the right to audit any SubContractor or Supplier at any time, giving notification to the Contractor and any intervening Co-Contractor.

Audits shall be performed according to predefined checklists.

The Contractor shall issue a report for each audit performed. The report shall include:

a. Overall conclusions.
b. Identification of areas of non-compliance or weakness.
c. Actions aimed at correcting the points identified above.
   The actions shall have defined completion dates and shall be clearly accepted by signature by the audited organization.
d. The completed audit checklist.

Each audit report shall be issued within 5 working days of the audit visit and one copy shall be sent to ESA at that time.

Corrective action8 identified by the audit shall be followed-up to the elimination of all discrepancies found.

83.9 TRAINING

The Contractor shall have trained and competent pereonnel to implement the PA proqramme. For this purpose, the Contractor shall establish a documented training proqramme for PA personnel and all other personnel whose performance determine or affect product quality.

In their PA plane, Contractor8 shall explicitly define:

- all technical activities calling for special skills,
- the method8 adopted in relation to the selection, training and certification of the relevant personnel and the manner in which their skills are to be maintained.

Records of training and Certification status Of personnel Shall be maintained and shall be available upon request.

B3.10 ESA / CONTRACTOR INTERFACE

The Contractors shall be responsible for generating, collecting, and recording the product assurance evidence and for demonstrating the achieved levels to ESA on request. The Contractor8 shall not impede ESA's performance of its monitoring and inspection function. In particular, the Contractors shall provide free access to resources and facilities necessary for authorized officer8 toundertake these activities. The Contractor8 shall ensure that his subContractors provide similar free access, resources and facilities when so required.

B3.11 ELECTRONIC PROCESSING OF DATA

The Contractor is encouraged to Collect, store, review and transmit Product Assurance Data by electronic means.

B3.12 STANDARDISATION

Common product assurance design rules, standards, methods (including R & S analyses), procedures, and data format8 shall be used by all Contractors.

83.13 VERIFICALIFICATION AND ACCEPTANCE

Verification is the process of showing that a requirement has been satisfied. Requirement8 verification shall be performed progressively, as each stage of the project is completed, and provide8 the organised base of data upon which qualification and acceptance will be incrementally declared.

Qualification is the formal recognition that an item design meets customer requirements, while Acceptance is the formal recognition of the item conformity to the qualified design.

B3.13.1 Structured Requirements

The Contractor shall establish and maintain a system for defining and relating the requirement8 in an organised manner. The eystem shall be aimed to ensure consistency and completeness of both: top-down requirements allocation and bottom-up requirement8 verification.

Traceability to ESA requirements and to verifications results shall be ensured. The Contractor shall describe in the PA plan how the traceability and verifiability of the requirements system will be achieved.

B3.13.2 Verification

The verification process will consist of:

- Verification of compliance between system design and Agency requirements.
- Verification that system design requirements are properly allocated to lower levels items.
- Incremental verification of items detailed design compliance to their approved design requirements up to system level.
- Incremental demonstration by test of items compliance to their approved design requirements up to system level, and validation of the "as designed" documentation.
- Conformity verification and reconciliation of the *as built" configuration to the "as design", for each item up to system level.

System and lower levels reviews represent the formal checking of the data provided by the verification process to finally decide whether the requirements have been fulfilled.

B3.13.3 Qualification

The process of qualification is defined as:

"Determination that the item is capable of meeting the established performance and design requirements with margins commensurate with the application and use environment."

The design is qualified by the customer when the collected evidence from tests, inspections, reviews, analyses, comparisonsprovethat requirements have been satisfied.

Qualification shall be achieved from the lowest level upwards so that at each level when qualification takes place, all applicable lower level items will have been previously qualified. Qualification shall apply to all deliverable items whether produced by the Contractor or his co/subContractors.

The Contractor shall track and record and periodically report to ESA, the qualification status of all deliverable items as well the progress of the qualification programme.

Qualification Tests

To obtain authorisation to initiate qualification tests the Contractor shall ensure that:

- the qualification test procedures *and* facilities are defined, available and conforming to requirements;
- pass/fail criteria are defined;
- data recording provisions are adequate;
- the configuration of the qualification item is compliant with the design standard configuration;
- all non-conformances have been notified to the Customer for approval;

- the qualification item documentation (log-book) is complete and available;

Qualification tests shall be performed in accordance with the detailed procedures authorised at the presentation.

All actions emerging from the qualification tests shall be completed to the satisfaction of the customer.

On completion of qualification tests, a qualification report shall be written which addresses all aspects of the activity and states the conclusions as to the technical proof actually demonstrated. The report shall be submitted for approval to the customer as the qualifying authority.

Maintenance of Qualification

Once the design has been qualified, all subsequent changes shall be reviewed for their impact on the qualification status.

Qualification by Similarity

Qualification by similarity may be accepted if the Contractor provides justification and evidence that the new set of requirements is within the limits of the previously qualified design.
When the new set of requirements is more stringent than those of the qualification, complementary qualification tests and justifications shall be provided to the customer for approval.

B3.13.4 Acceptance

Acceptance activities shall be carried out in accordance to PSS-01-20.

B 4 RELIABILITY AND SAFETY

B4.1 R & S MANAGEMENT

The Contractor shall carry out, in an integrated way, the different tasks described in this specification for reliability and safety.

Risk to human life, investment, environment and mission shall be controlled according to the following sequence.

- allocation of R & S requirements,
- risk identification,
- risk evaluation,
- risk reduction, and
- risk acceptance and management.

This shall be a continuous and iterative process, based on both qualitative and quantitative analyses and shall take advantage of experience acquired in the course of other similar programmes.

B4.2 R & S ENGINEERING

B4.2.1 Integration of R & S into Project Activities

R & S engineering shall be involved in trade-off studies between alternative technical solutions, and shall remain involved throughout all project phases including contributions to, and feedback from, integration and test operations.

R & S engineering shall provide inputs for the generation of design specifications, and shall review them for compliance with R & S requirements.

R & S engineering shall participate in the internal and external interfaces activities.

The risk reduction and risk control processes shall be the joint responsibilities of the PA and Engineering teams.

R & S analyses shall be signed off by the PA Manager and the Engineering Manager.

B4.2.2 R & S Analyses

Risk identification and evaluation in relation to mission technical success and safety shall be undertaken using the reliability, and the safety analyses required in this specification.

In the interests of exhaustive analysis, these methods shall be combined in order to allow complementary approaches, namely top-down and bottom-up:

- using a given undesirable event or consequence as a starting point, top-down analysis will be used to identify causes,

- using a given single cause or combination of causes as a starting point, bottom-up analysis will be used to identify undesirable events and its consequences.

Prime Contractor shall put forward a recommended level of overlap between these analyses both to facilitate the comparison of results and make the analyses more exhaustive.

In the case of quantitative analyses, the Contractor shall take into account the uncertainties associated with the data and use them to conduct sensitivity studies.

The different analyses shall take into account relevant experience acquired in the course of similar programs.

B4.3 R & S ASSURANCE

R & S Assurance shall demonstrate that:

- the R & S objectives and requirements comply with the needs,
- the means adopted are compatible with the objectives,
- the methodologies are appropriate,
- actions and recommendations are duly undertaken and followed through to completion,
- all identified risks are controlled and acceptable in accordance with programme requirements,
- all activities are duly documented in accordance with the contractual requirements.

The Prime Contractor shall define a system for the identification, recording, follow-up, processing and formal close-out, of risk reduction actions and recommendations arising out of R & S activities, in the PA plan.

The status of these actions and recommendations shall be periodically presented to ESA. As a minimum, this status data will be presented at project reviews.

B4.4 R & 8 PLAN

The Contractor shall prepare a R & S plan in accordance with both the contract and the applicable requirements.

The R & S plan shall define the R & S programme to be implemented and describe the manner in which the Contractor is to carry out the different tasks then verify that they have been properly executed.

Each R & S activity shall be identified, the corresponding implementation method summarized, and the implementation schedule defined in terms of the project life cycle.

The plan shall define the R & S organization and responsibilities, particularly as regards:

- the relationships between the different aspects of R & S (Reliability, and Safety),
- the relationships between R & S and the other aspects of PA (including configuration control),
- the relationships with the other aspects of the project (engineering, manufacturing, testing).

The plan shall also describe how the different R & S activities are to be defined and controlled at the lower contractual levels.

The plan shall ehow how the safety rules and standards applicable to the different activities and sites involved in the course of the project will be complied with.

B4.5 SAFETY ASSURANCE

PSS-01-40 applies with the following modifications:

PSS-01-40, section *2* "Applicable *documents"*
PSS-01-400, PSS-01-403, PSS-01-404, PSS-06-20, SLP/2104 shall not be considered as applicable.
PSS-01-402 shall be considered as a reference document.

PSS-01-40, section I-2 *"Safety* Assurance Organization *and* Management"
Add: " The Safety personnel shall be part of the product assurance team"

PSS-01-40, section I-4 *"System* safety *programme plan"*
Add: "The safety programme plan shall be an integral part of the *R & S* plan as defined in this specification."

PSS-01-40, section *I-6* "Project technical safety specification"
The project technical safety specification shall be an integral part of design specification.

PSS-01-40, section I-7 "Safety assurance"
All references to PSS-01-400, PSS-01-403, PSS-01-404 shall be deleted

PSS-01-40, section I-7.1 *.1.1* *Hazard consequence severity categories"
Change "critical" to "serious".

PSS-01-40, section I-7.4 "Identification *and* control of safety-critical functions and safety critical items*
Delete the first paragraph and replace by the following:
"The following definitions shall apply:
Safety critical function: function that if lost or degraded, or which through incorrect or inadvertent operation, would result in a catastrophic or serious consequence.
Safety critical item: items or procedures which support a safety critical function, but which do not comply with the applicable requirements for safety, or which cannot be verified as complying with those requirements."

Last bullet starting from "assembly, ...": "safety critical items" shall read as "items supporting safety critical functions"

PSS-01-40, section I-7.5 "Safety validation and qualification testing"
In this section, "safety critical items" shall read as "items supporting safety critical functions"

PSS-01-40, section I-7.10 "Safety reviews *and* meetings"
Not applicable

PSS-01-40, section II *"System level technical requirements"*
The requirements in this section II are superseded by the technical requirements in the S.O.W.
Annex 1 should be used as a reference
Annex 2 is applicable
Annex 3 is applicable as tailored in the SOW
Annex 4 "Definitions" is applicable with the modifications listed earlier in this paragraph and the following ones :
Definition of "Operator Error" to be replaced by the following one : "The failure *of* an operator to perform an action as required or trained"
Add the definition of "Failure": "The inability of a system to perform as specified. Failure can originate from hardware, software, firmware or procedures or can be caused by natural or induced environmental effects."

B4.5.1 Fracture Control Requirements

PSS-01-401 applies with the modifications identified in Annex A to the SOW (para 4.11) plus
Para 4.4 Document Requirements

'A Fracture Control Plan identifying items concered and documents which will later contain the relevant analysis and test results shall be delivered as part of the PDR package. The actual analysis and test report shall be part of the CDR package'.

B4.6. RELIAIBLITY ASSURANCE

PSS-01-30 applies with the following modifications:

When in PSS-01-30 reference is made to PSS-01-10, this should read as a reference to the present specification.

PSS-01-30, para. 1.3 "Applicable *documents"*
PSS-01-303 is not applicable.

PSS-01-30, para. 2.2 "Basic approach"
- delete item j

PSS-01-30, *para.* 3.2 "Reliability *programme plan"*
Add: "The reliability programme plan shall be an integral part of the R & s plan as specified in this specification."

PSS-01-30, para. 4.4 "Functional *analysis"*
Replace bullet d) by the following:
"d) As a result of Functional Analysis, reliability critical and safety critical functional paths shall be identified.

PSS-01-30, para. 4.5 *"Failure* effect severity categories"
The part of this paragraph from "The rule of the ..." till "Unscheduled maintenance . .." shall be replaced by the following :
"Any reference to the FESC shall be intended as reference to the Consequence Severity categories defined in the Safety Assurance chapter of this document."

PSS-01-30, *para.* 4.6 "Failure tolerance"
Not applicable. The failure tolerance requirements applicable to METOP-1 are given in the S.O.W.

PSS-01-30, *para.* 4.9 "Reliability Apportionment and Prediction"
Delete from, "The reliability prediction . . ..up to...specified in PSS-01-401"

PSS-01-30, *para.* 4.10 "Failure modes, Effects and Criticality Analysis *(FMECA)"*
Reference to PSS-01-303 shall be deleted

PSS-01-30, *para.* 4.12 "Analysis data *base"*
NPRD-91 shall be used as a reference for non-electronic parts reliability data.

PSS-01-30, *para.* 4.13.1 'Reliability Critical Items *(RCI)* and Reliability Critical Items List *(RCIL)"*
Delete first sentence including bullets a), b),c). and replace by the following:
"The following definitions shall apply:
Reliabilitv critical function: function that if lost or degraded. or which through incorrect or inadvertent operation, would result in major consequences.
Reliability critical item: items or procedures which support a reliability critical function, but which do not comply with the applicable reliability or availability acceptance requirement8 given in the S.O.W. or which cannot be verified as complying with those requirements."

PSS-01-30, pars. **4.17** *"Contingency* ***analysis"***
Not **applicable during phase B.**

PSS-01-30, para. 4.19.2 "Human **reliability** ***modelling"***
Quantitative modelling of human reliability is not required during phase B.

B5. QUALITY ASSURANCE MANAGEMENT

PSS-01-20 applies with the following modifications:

When in PSS-01-20 reference is made to PSS-01-10, this should read as a reference to the present specification.

PSS-01-20, para. 1.3 *"Applicable documents"*
PSS-01-001, PSS-01-12 are not applicable.

Pss-01-20, *para.* 1.4 *"Definitions"*
Not applicable.

PSS-01-20, *para.* 2.1 "Quality assurance *programme"*
Last sentence: delete "in accordance with PSS-01-12

PSS-01-20, para. 2.3 "Quality *assurance programme plan"*
Add : "The quality assurance progranune plan shall be part of the product assurance plan."

PSS-01-20, para. 5.4.1.2 "Audit Checklists"
Replace by: "Audit shall be performed according to predefined checklists".

B6. PARTS. MATERIALS AND PROCESSES

86.1 EEE PARTS SELECTION AND PROCUREMENT

PSS-01-60 applies with the following modifications :

*PSS-01-60 para. 3.7 *Experience Summary Report"*
Not relevant to Phase B.

PSS-01-60 para. 4.7.3 "Preferred components"
Whole paragraph to be deleted and replaced by the following :
"The Prime Contractor shall compile an METOP-1 EEE Preferred Parts List (METOP-1-PPL) . This list shall contain an adequate range of components drawn from existing qualified and preferred parts lists, current programmes and new technologies where sufficient qualification data is available.

The ESA Preferred Parts List ESA-PSS-01-603, shall be used as the primary basis for components selection
The METOP-1-PPL shall be submitted to ESA for approval and shall be maintained under configuration control by the Prime Contractor."

PSS-01-60 *para.* 4.7.4 "Non *PPL Listed Components"*
*'Replace 'PSS-01-603' by 'METOP-1-PPL' ".

PSS-01-60 *para.* 4.10.3 *"Ground Support Equipment"*
Replace whole paragraph by the following :
"The requirements laid down herein are also applicable to the components of ground support equipment with direct physical interface with the space vehicle.
The requirements for the non interfacing components in ground support equipment shall be specified by the prime Contractor in accordance with the related reliability and safety requirements".

PSS-01-60 para. 5.5.2 *"Destructive* Physical Analysis *(DPA)"*
Sentence "If not requested otherwise by the contract, three additional samples from each lot / date code shall be procured and supplied to ESA" to be deleted and replaced by the following :

"Three additional samples from each lot/date code shall be procured and kept in stock as reference for further investigation by ESA or Contractor in case a problem/failure arise on the lot".

*PSS-01-60 **para .5.6 "Components failures"***
Replace paragraph by the following:
"Components failures shall be dispositioned in accordance with the requirements of PSS-01-20. The classification of component non conformances shall be as follows:

- When a batch or a lot of components exceeds the rejection criteria of the procurement specification before delivery to the procurer or user, the non conformance shall be classified as MAJOR if it is proposed that the batch or lot is still considered for delivery.

- At incoming inspection the following non conformances may be classified as MINOR:
  - isolated components with single electrical characteristics slightly out of specification. Where there is more than one component per lot or batch with the same characteristic out of specification, this shall constitute a MAJOR non conformance.
  - cosmetic visual defects where the form, fit, function and reliability of the component are not affected.
  - minor inconsistencies in the documentation such as missing items where the supplier agrees to supply the missing documents. This does not remove the need to quarantine the delivered components until any missing data are supplied and checked.

All other non-conformances discoveredafter delivery from the manufacturer (Including DPA) shall be classified as MAJOR."

86.2 MATERIALS, MECHANICAL PARTS, PROCESSES (MMPP)

PSS-01-70 and PSS-01-700 applies.

PSS-01-701 is to be used as guidelines.

B7. *SOFTWARE* PRODUCT ASSURANCE MANAGEMENT

PSS-01-21 applies with the following modifications:

PSS-01-21 para. 1.3 *"Applicable Documents"*
PSS-01-10 and PSS-01-50 shall not be considered as applicable.

PSS-01-21 pare. 3.4 *"Software product assurance procedures"*
Applicable with the following changes:
bullet f) shall read: "Classification - procedures to classify a software product according to its functional criticality"

Pss-01-21 para. 3.5 *"Software* classification"
Replaced by the following :

"Software shall be classified according its functional criticality using the applicable safety and reliability consequence severity categories."

"The classification system should also take into consideration other factors (i.e. cases of complexity, size, language, type of application , etc)."

"The classification system shall be approved by ESA."

"A list of the software and the resulting classification of each unit / component / item shall be produced and kept up-to-date by the Contractor. This list shall be a deliverable item."

PSS-01-21 *para.* 3.6 "development statistics" (for phase C/D)

Replace the four first lines by the following :
"The Contractor shall set up a system for gathering data and development metrics throughout the "Custom" software development cycle. The metrics shall (at least) cover the following:"

Points a) through f) of para. 3.6 of PSS-01-21 remain valid. In applying points e) and f) concerning effort and cost, only relative values shall be deliverable to ESA.

Add "The Contractor shall describe in the Software PA Plan the metrics to be gathered and how they will be used."
"The Contractor shall analyze the collected development data to provide evidence that the development *of* the software is conforming to the requirements.*

PSS-01-21 para. 3.7 *"Subcontracted* and *purchased software"* (for phase C/D)
Supplemented by the following:

"The evaluation of COTS or "Reusable" software Suppliers shall cover the Supplier's capability for ensuring COTS software maintenance for the duration *of* the programme, for which the software is being purchased, and at the same time the Supplier's general policies concerning :

.(a) maintenance and procedures for keeping customers informed of product changes,
(b) licensing arrangements."

"The selection of COTS or "Reusable" software and Suppliers shall be based on the combined evaluation of the software and the Supplier."

"The Contractor purchasing a COTS or "Reusable" software product shall issue a procurement Requirements Document which shall be submitted to the Customer for acceptance."

"The Prime Contractor shall establish a format for the Procurement Requirement Document."

"Each COTS or "Reusable" software product shall be evaluated by the Contractor that purchases it. The evaluation shall cover:

(a) analysis of special conditions associated with the product (access restrictions, confidentiality clauses, renewable licenses, etc.),
(b) references concerning the use of the same products in other projects or applications.
(c) compliance with the applicable requirements as defined in this document.
(d) available documentation."

"The Contractor purchasing COTS or "Reusable" software shall ensure that the supplied documentation meets the requirements of the project."

"The Contractor shall modify or re-issue documentation of COTS or "Reusable" software if the available documentation does not satisfy the project's needs."

Add para. "3.8: *Standards , Methods and* Production *Tools"* (for phase C/D)

"A common SDE shall be proposed by the Contractor, for approval by ESA (TBC)"

"Preference shall be given to the tools and methods available through the use of a Software Development Environment (SDE) for "Custom" software development."

"The use of a SDE shall be mandatory if the software to be developed is classified as a Critical Software."

"Software development tools, other than those available through the SDE, shall only be used following ESA approval."

" If "non-deliverable" software is used during development and test, the non-deliverable software shall be identified and its use and purpose shall be documented."

Add the *following* para "3.9 *Software* Quality Factors" (for phase C/D)

"A selection of software "Quality Factors" shall be proposed for approval by ESA to establish, at requirement level, the characteristics that the software product shall exhibit for the acceptability of the product by the Customer. Appendix C shall be used as a reference for the selection of "quality factors""

Add para. "3.10: *Configuration* Management" (for phase C/D)

"Documentation configuration management shall, in particular, ensure that it is always possible to establish the traceability between the versions of the computer codes (source code, object or machine code), the versions of the associated documents and the versions of the development tools."

Add para. "3.11: Software Archiving and Library management" (for phase C/D)

"The Contractor shall define the methods and the provisions for:
(a) software (and software documentation) archiving and safe-keeping.
(b) software protection against unauthorized or malicious access."

Add para. "3.12: *Software* Reliability"

"For each software product the validation Of software Reliability shall be provided primarily by means of software testing. Analytical data and design proof can only support such validation effort.'

" Fault Tolerance:"

"The required level of fault-tolerance for software shall be specified in the relevant sections of the Software Requirement Document (SRD)."

"The fault hypotheses on which the design of the fault-tolerance mechanisms is based shall be clearly defined in the corresponding Architectural Design (ADD) and Detailed Design (DDD) documents."

"The Contractor shall ensure that redundant software products are designed and produced by independent teams and that the methods and algorithms used are sufficiently diversified to avoid common-mode failures."

PSS-01-21 para. 4.1: "Requirements definition"
"Software ESA PA shall..." should read "Software PA shall..."

PSS-01-21 Appendix A: "Definitions"

Modify the following definitions:

Reliability critical **software**: Software supporting a reliability critical function.

Safety critical software: Software supporting a safety critical function.

Add the following definitions:

Supplier : the COTS software vendor.

Software Types :

- **"Deliverable"** software: a software product developed according to a Software Requirements Document, and supplied, or intended to be supplied, by one Contractor to a Customer.

  Under deliverable software the following two sub-types are identified:

  (a) "<u>Custom</u>" software: a software developed within the framework of an ESA's programme.
  The development life-cycle for "Custom" software and the associated deliverable documents are defined in PSS-05-O.
  (b) "<u>Reusable</u>"software: a *software* developed within the framework of a space programme and which is reusable by another programme.

- **"Non-deliverable"software**: a software developed or used by a Contractor (for its own purposes) and which is not intended for delivery to ESA.

Commercial Off **-The-Shelf** (COTS): a software possessing all of the following features :

(a) belongs to a Supplier's catalogue,
(b) marketed as an "off-the-shelf' software product,
(c) usable **"as it is"**,
(d) references are available concerning its use outside the context of ESA's programmes,
(e) corresponds, for its functionality, to an issued Requirement Document.

Depending on the circumstances, COTS software may be deliverable or non-deliverable.

Add Appendix C: Software quality *factors:*

'Quality *Factors are* ***characteristics which*** a software product exhibits that reflect the degree of acceptability of the product to the Customer. Below is a list of the most relevant Quality Factors.(User oriented factors)."

reliability :	the rate of failures of the software that render it unusable.
maintainability	ease of finding and fixing errors.
efficiency:	economy of resources needed for carrying out specific functions.
correctness :	conformance of software design and implementation to stated requirements.
verifiability :	ease of verification of functionality against requirements.
portability:	ease with which software can be transferred from one hardware environment to another,
flexibility:	capability for successful evolution outside the project specification,
couplability:	ease of coupling the software with software in other systems or applications.
reusability:	ease with which software can be reused, wholly or in part, for non-specified applications.
expendability :	ease of maintaining the software to meet new functional or performance requirements.
integrity :	security against unauthorized access and/or wrong input data.
usability :	ease of learning to use the software and preparing input and interpreting output.
survivability :	continuity of reliable execution in presence of external failure."

B8. CONFIGURATION MANAGEMENT

The Configuration Management Requirements are defined in PSS-01-11.

STATEMENT OF WORK AND TECHNICAL REQUIREMENTS

ANNEX C

METOP SATELLITE TO GROUND SEGMENT INTERFACE SPECIFICATION

Prepared by: METOP Team

Approved by: EUMETSAT

Approved by: P.G. Edwards

METOP Project Manager
Earth Observation Projects Department

CONTENTS LIST

C1. INTRODUCTION

C1.1 APPLICABLE DOCUMENTATION

This document is intended to provide the METOP Contractor (and the Ground Segment Contractors tbd) with communication and operation requirements that apply to the interface between the METOP-1 Space Segment and the Ground Segment.

During the METOP project lifetime, the interface between ground and spacecraft shall be controlled via this document.

C1.2 GENERAL MANAGEMENT REQUIREMENTS

AD0	tbd	Specific requirements for HRPT and LRTP and Encryption for METOP.
AD2	MO-RS-ESA-SY-0023	Satellite System Requirements (Annex A of SOW)
AD3	MMS/MET/TN/JLD/160.94	Instrument Interface Control Document

C1.3 REFERENCE DOCUMENTS

RD01	CN-IA-TN-1.0.1.2-61-IPT	IASI Instrument Data List
RD02	GE IS-2617547	Unique Instrument Interface Specification for AMSU-A1
RD03	GE IS-262 4403	Unique Instrument Interface Specification for AMSU-A2
RD04	EPS/MHS/SPE/93002	MHS Interface Specification
RD05	GE IS-20029950	Unique Instrument Interface Specification for AVHRR-3
RD06	GE IS-2285780	Unique Instrument Interface Specification for HIRS-3
RD07	GE IS-3267400	Unique Instrument Interface Specification for SEM
RD08	GE IS-3267402	Unique Instrument Interface Specification for DCS-2
RD09	GE IS-3267401	Unique Instrument Interface Specification for SARP
RD10	GE IS-2295546	Unique Instrument Interface Specification for SARR
RD11		ScaRaB Data List
RD12	OPS-MN-310-m	Operation Facilities Document
RD13	EPS/GRE/REQ/93002	EPS Ground Segment Technical Specification
RD14	TBD	MIMR Data List
RD15	TBD	ASCAT Data List

RD16	TBD	OMI Announcement of Opportunity

Cl.4 STANDARDS

SD01	PSS-04-103	Telemetry Channel Coding Standard
SD02	PSS-04-101	ESA Packet Utilisation Standard
SD03	PSS-04-105	ESA RF Modulation Standard
SD04	PSS-04-104	ESA Ranging Standard
SD05	PSS-04-106	ESA Packet Telemetry Standard
SD06	PSS-04-107	ESA Packet Telecommand Standard
SD07	PSS-04-108	Advanced Orbiting Systems, Network and Data Standard
SD08	PSS-04-151	Telecommand Decoder Specification

Cl.5 DOCUMENT STRUCTURE

This document has the following structure:

- Chapter 2 describes the communication links (S-band, X-band and direct broadcast links) using the concept of layer hierarchy defined in SD07.
- The application processes for S-band Telemetry and Telecommand are described in the Telecommanding and Monitoring chapters (3 and 4).
- Chapter 5 lists the operational requirements on the satellite and the payload.

Complementary information on the spacecraft (orbit parameters...) and ground system requirements shall be found in AD02 and RD13.

This Interface Document does not take S&R and DCS links into account.

Cl.6 GENERAL REQUIREMENTS

The power flux density generated by the satellite at the surface of the earth shall be in accordance with the Radio Regulations Article 28, Section 4.

Provision shall be made to keep the out of band spectral components falling in the Radio Astronomy Bands and in the Deep Space Network Band within the limit specified in the CCIR Report 224-7, 1990 and the CCSDS recommendation, CCSDS 401 (XX) R-l, April 1989.

The satellite link budgets shall be produced in accordance to the ESA PSS-04-105.

The satellite shall be designed in order to guarantee the following margins in every link budget:

- 3 dB on nominal parameters
- 1 dB for worst case parameters

C2. LINKS REQUIREMENTS

C2.1 OVERVIEW

The METOP satellite communicates with G/S facilities by means of four links: two of them for data broadcast - LRPT in VHF and HRPT in UHF -, one for data dump in X-Band and one for TT&C in S-Band.
The EPS Ground Segment comprises a high northern latitude main CDA station (Kiruna shall be used as the design case) performing the command and control of the METOP satellite during nominal operation (TM, TC and ranging) and acquiring the satellite X-band recorded science data. During nominal operations, the use of Kiruna shall allow 10 visible orbits per day of a maximum duration of 11 minutes.

The main CDA station is complemented by a backup CDA station on another northern european side (e.g. Tromso, Svalbard -tbc) having the same facilities. The acquisition of global science data for orbits which are not covered by the european CDA stations is performed by the NOAA Ground Segment CDA station of Fairbanks or Wallops (Gilmore). In a similar way the acquisition of NOAA satellites' blind orbits is made by the EPS Ground Segment part of the same global support for the reception and exchange of data from the morning and afternoon polar missions.

As option, the ground segment shall be considered composed by a single antenna located in Svalbard (78.22N, 15.45 E) which allows a data dump every orbit.

The TTC subsystem performs telemetry and telecormnand communication between the METOP satellite and the ground, and supports 2 ways doppler tracking and ranging of the METOP satellite by the ground.

The two EPS CDA stations will be complemented by an existing european TTC network for mission phases or activities which require additional TTC coverage such as LEOP, orbit manoeuvre and in case of non-nominal operation.

C.2.2 INSTRUMENTS DATA ACQUISITION AND DISTRIBUTION

The Payload Data Handling subsystem acquires CCSDS packetised data from each instruments and multiplex these data into the HRPT, LRPT and Global Data stream.
Table C.2.2/1 summarises the instrument packetised data rate and the distribution service through the three links.

Instrument	Global Data (Kbit/s)	HRPT Q (Kbit/s)	HRPT I (Kbit/s)	LRPT (Kbit/sec)
IASI	1504.200	1504.200	-	-
MHS	3.840	-	3.840	3.840
ASCAT	45.000	-	45.000	-
MIMR	100.000	-	100.000	-
OMI	50.000	-	50.000	-
SCARAB	3.000	-	3.000	-
AVHRR High resolution	621.540	-	621.540	-

AVHRR Low resolution	33.300	-	-	33.300
AMSU A1	2.108	-	2.108	2.108
AMSU A2	1.148	-	1.148	1.148
HIRS	2.896	-	2.896	2.896
DCS	2.574	-	2.574	2.574
HK Data	4.000	-	4.000	4.000
Administration messages	1.500	-	1.500	1.500
Encryption messages	-	tbd	tbd	tbd
Total (w/o encryption messages)	2370.906	1504.200	837.606	51.366
Overhead (16.1%)	381.714	242.180	134.054	0.264
Total	2752.620	1746.380	972.460	59.630

Table C.2.2/1

C2.3 COMMAND AND RANGING UPLINK

SD-6 and SD-S are the applicable standards for the Telecommand link.

The Telecommand System follows the communication protocol and services defined in SD06.

It is organised in independent layers providing services to the layer above:

- a Packetisation layer which organises the data provided by the Application Process into a TC packet. Chapter 2 deals only with the packetisation format (the source data unit). The application process itself is described in chapter 3 and 4;

- a Segmentation Layer which segments these TC packets, route and multiplex them as TC segments. It is equivalent to the CCSDS Network layer;

- A Transfer layer which uses Transfer Frames (TF) as transmission mechanisms including error control mechanisms like CRC (cyclic redundancy code) or ARQ (automatic request for retransmission): the procedure used for TC is COP-l. Reporting is done via CLCW (Command Link Control Word) in the Telemetry. It is equivalent to the CCSDS Data Link layer;

- a Coding layer providing forward error detection and correction using CLTU (Command Link Transmission Unit);

- a Physical Layer.

C2.3.1 Packetisation Layer

The Packetisation layer organises source data defined above into TC packets with a packet header an error control field.

Packet Header (48 bits)			Packet Data Field (variable)		
Packet id	Packet sequence control	Packet length	Data Field Header	Application Data	Packet Error Control
16	16	16	variable	variable	16

Packet id

- Version number	000 (version number 1)
- Type	1 (TC)
- Data Field Header Flag	0 = absence; 1=presence of a header
- Application Process id	tbd

Packet sequence control

- Sequence Flag	tbd
- Packet name/sequence count	tbd
- Data Field Header Flag	

Packet length tbd

The PSS allows Packet length up to 65536 bytes but it is recommended to limit the size to 256 bytes for operational and coverage duration reasons.

C2.3.2 Segmentation/Network Layer

The Segmentation/Network layer provides the segmentation of TC packets which are too large for direct insertion into a Transfer Frame and multiplexing onto Virtual Channel.

A TC Segment of 249 bytes fixed length consists of:

a Header:	1 bytes
a Data Field:	240 bytes

The authentification function is required.

C2.3.3 Transfer/Data Link Layar

The Transfer layer provides the error free data transfer: forward error correction and synchronisation. Each TC segment is embedded in a TC Transfer Frame.

A Transfer Frame is composed of:

a Frame Header:	5 bytes
a Frame Data Field:	249 bytes
a Frame Error control Field:	2 bytes

C2.3.4 Coding Layer

The coding layer provides forward error correction capability as well as synchronisation services at the receiving end.

TC frames are sent to the coding layer and embedded/encoded into CLTU (Command Link Transmission Unit) which is the Coding layer protocol data unit.

A CLTU is made of:

- a 16 bit Start Sequence which marks the beginning fo a CLTU (sync service) = HEX 'EB90'
- one or more TC blocks of 8 bytes (with 7 bytes of information followed by an error control field of 1 bytes)
- a Tail sequence of 8 byte which marks the end of the CLTU.

C2.3.5 Physical Layer

TC uplink shall be possible via the nominal TC S-Band. Link budget shall be computed for a slant range up to 3000 km.

The applicable standard is SD03

carrier frequency:	TBD in the 2025 -2110 MHz band
polarisation	LBCP for the earth facing antenna and RBCP for the other antenna
axial ratio	4 dB for $0<\theta<90$; 6 dB for $90<\theta<105$
spacecraft G/T	-64 dB/K TBC
G/S EIRP	TBD
data rate	2 kbit/s
data modulation	NRZ-L-PSK
carrier modulation	PM
subcarrier frequency	8 or 16 KHz (sinewave)
modulation index	0.6 rad pk (TBD)
data quality	probability of a rejected frame better than 10^{-5} probability of undetected frame error better than 10^{-19} BER on physical channel better than 10^{-5}
total channel degradation	2.6 dB
carrier modulation loss	10 dB
contact duration	5' - 11' per station
spectral mask for TC signal	TBD
G/S radiated spurious	TBD

C2.3.6 Ranging Uplink

The applicable standard is SD04.

The TTC sub-system supports 2 doppler tracking with a coherent transponder (which can also be used in non coherent mode). In coherent mode, the downlink frequency is derived from the receiver VCXO which is phase synchronised with the uplink frequency using phase-lock techniques.

The receiver mode - coherent or free running - is selected by ground commands.

The ground station shall compute the position of the spacecraft with:

- propagating ephemeris;
- pursuit data using doppler measurements on the receiver carrier frequency to estimate the relative speed of the satellite when the satellite transponder is used in coherent mode;
- ranging code acquisition and tracking.

Earth to space link requirements (from SD04 and SD03)	
Tone frequency range	100 kHz-1.5 MHz
code length	tbd
Modulation scheme	PCM/PSK/PM
Tone modulation index	45° (ambiguity resolution) or 28° (measurement phase)
carrier modulation index	cl.2 rad peak nominal ranging only

C2.4 TM AND RANGING DOWNLINK

SD01 and SD05 are the standards applicable for the TM link.

C2.4.1 Packetieation Layer

The Packetisation layer organises source data into TM Source Packets with a packet header and an error control field.

TM source packets format is as follows:

Version No = 000	Packet id	Packet sequence control	Packet data length	Packet secondary header	Source data	Error control field optional
Packet Primary Header (6 bytes)				6 bytes	variable	2 bytes

Packet id

- Version number	000 (version number 1)
- Type	0 (TM)
- Data Field Header Flag	0 = absence; 1 = presence of a header
- Application Process id	tbd

Packet sequence control

- Sequence Flag	tbd
- Packet name/sequence count	tbd
Packet length	tbd

The PSS allows Packet length up to 65536 bytes but it is recommended to limit the size to 10000 bytes (GFSC-480-72) for operational and coverage duration reasons.

Packet secondary header	contains Unsegmented Time Code for time tagging.
Error control field	contains CRC (tbc).

C2.4.2 Segmentation/Network Layer (optional)

The main functions are segmentation of packets in order to allow encapsulation into Transfer frame (data link layer) and multiplexing allowing different sources of TM packets to be multiplexed on the same data link. Segmentation applies on the Source data field only. No encryption service is required on the Housekeeping TM downlink.

The output is a TM Source Packet Segment.

C2.4.3 Transfer/Data Link Layer

The Transfer layer provides mechanisms for the optimal transmission of transfer frames: it contains spacecraft identification, sequence control, flow control, error detection and recovery procedures.

The output is a TM Transfer frame:

Transfer Frame primary header (6 octets)				
Version No 00	Transfer frame id	Master channel count	Virtual channel count	Data Field status

T F secondary Header (up to 64 bytes	Data Field Application data variable	Operational control field data 4 bytes	Frame error control field 2 bytes

C2.4.4 Coding Layer

No coding required.

C2.4.5 Physical Layer

The applicable standard is SD03

carrier frequency:	TBD in the 2200 - 2290 MHz band
frequency ratio (f_{up}/f_{down})	221/240
polarisation	LHCP for the earth facing antenna and RHCP for the other antenna
axial ratio	4 dB for $0<\theta<90$; 10 dB for $90<\theta<105$
spacecraft EIRP	-24.6 dBW TBC
Ground Station G/T	TBD
data rate	4096 bit/s TBC
data modulation	NRZ-L-PSK
carrier modulation	PM
subcarrier frequency	65.536 KHz (sinewave)
modulation index	1 rad pk TBC
required BER	10^{-6}
total channel degradation	1.5 dB
maximum PFD	-154 $dBW/m^2\bullet 4KHz$ for $0<\delta<5$ -154 + $0.5\bullet(\delta-5)$ $dBW/m^2\bullet 4KHz$ for $5<\delta<25$ -144 $dBW/m^2\bullet 4KHz$ for $25<\delta<90$
spectral mask for TM signal	TBD

C2.4.6 Ranging Downlink

The applicable standard is SD04.

C2.5 GLOBAL DATA DOWNLINX (X-BAND)

The Global data link follows the CCSDS standard for Network and data link layers as defined in SD07, it is coherent with AD-2.

C2.5.1 Application Layer

The following application id will be provided on the GDL as a minimum (excluding platform parameters) ; they will be associated to dedicated VCDU id:

APPLICATION		APID	VC id
Housekeeping data:	administrative messages	0	0
Housekeeping data:	commanded memory dumps	1	0
Housekeeping data:	non-nominal realtime telemetry	2	0
Housekeeping data:	extended history data	3	0
Housekeeping data:	nominal realtime telemetry	4	0
Housekeeping data:	orbit and attitude data	5	0
Housekeeping data:	ancillary data (tbd)	6	0
Instrument data:	MHS	34	12
Instrument data:	DCS-2	35	3
Instrument data:	HIRS/2	38	3
Instrument data:	AMSU-A1	39	3
Instrument data:	AMSU-A2	40	3
Instrument data:	AVHRR High Resolution (one Apid for all channels)	103	9
Instrument data:	AVHRR Low Resolution (3 of 5 channels; one Apid per spectral range)	71...75	5
Instrument data:	AVHRR telemetry data (3 channels; one Apid per spectral range)	76...80	5
Instrument data:	IASI	128	10
Instrument data:	ASCAT	tbd	15
Instrument data:	MIMR	tbd	17
Instrument data:	OMI	tbd	18
Instrument data:	ScaRaB	tbd	22

The secondary header is used with all APIDs. The secondary header is a time stamp, formatted as a CCSDS unsegmented time code, resulting in a length of 48 bits.

Application Data Rates

The subsequent table provides an overview of the data rates for all APIDs. It contains: the overall size of one source packet (CP_SDU) the number of source packets forming one data set. The source packets belonging to one data set are logically connected with help of the sequence flags.

All data sets except APID 0 are repeated one or more times every eight seconds. APID 0 data appears at a reduced repetition rate which is once per 64 seconds.

APID	Packet size/ bytes	Number of packets per data set	Number of data sets per 64 seconds	Notes
0	1038	1..8	1	number of packets may vary depending on operational requirements; budgetary estimate: 4 packets per data set
1	431	1..26	variable	one of the APIDs 1,2,3 will be used at a time
2	431	1..26	variable	see APID 1
3	431	1..26	variable	see APID 1
4	266	1	64	
5	86	1	64	
6	526	1	8	
34	1280	1	24	
35	2574	1	8	
38	2894	1	8	
39	1054	1	16	
40	574	1	16	
103	12928	3	128	
tbd	tbd	tbd	tbd	Climate Instrument Data
128	5014	1	2400	
71...75	970	1	256	AVHRR Low Rate data: each set contains data of one channel
76...80	20	1	4	AVHRR telemetry data: each set contains data of one channel

C2.5.2 Network Layer

The network layer is represented by the path layer defined for CCSDS advanced orbiting systems.

The CCSDS path service data unit (CP_SDU) is directly forwarded through the network layer as CCSDS path protocol data unit (CP PDU). The path layer shall generate the correct VCDU-IDS upon forwarding CP_PDUs to the multiplexing service on the transmitting side of the communication link.

The VCDU-ID is a data structure of 14 bits length, consisting of a spacecraft identifier (8 bits) and a virtual identifier (6 bits).

Spacecraft identifiers are assigned as follows:

Spacecraft	Spacecraft Identifier
METOP1	[TBD]
METOP2	[TBD]

The virtual identifiers are given in 2.4.1. Note that one additional virtual channel (63) is used by the data link layer for addressing fill VCDUs.

The application process identifier (APID) included in the CP_SDU is used as path id.

The CP_PDU structure consists of a packet header (6 bytes in length), a secondary header and a source data field followed by a two octet packet error control field.

Existence, structure, and length of the secondary header may depend on APID and mission.

The source data field is variable in length. The length of secondary header plus source data field must be an even number of bytes, not exceeding 9998.

The packet error control field consists of a cyclic redundancy checksum (CRC), computed over the primary header and the source data field.

Segmentation shall be used when one set of application data does not fit into one maximum size source packet.

The elements of the packet header are as follows:

version	set to 0 to specify version -1 CCSDS packet
type	set to 0
secondary header flag	set to 0, to indicate that no secondary header is present set to 1. to indicate that a secondary header is present
APID	see 2.4.1
sequence flags	set to 3, if the source data field contains one unsegmented application data set; set to 1, if the source data field contains the first segment of one segmented application data set extending through subsequent packet(s) ; set to 0, if the source data field contains a continuation segment of one application data set still extending through subsequent packet(s); set to 2, if the user data field contains the last segment of an application data set beginning in an earlier packet.
packet sequence count	sequential count modulo 16384, numbering the packets on the specified logical data path specified by the APID.
packet length	length of secondary header, source data field, and packet error control field in octets minus 1. All odd values between 3 and 9999 are allowed.

C2.5.3 Data Link Layer

The data link layer is implemented by the space link of the space link subnetwork specified by CCSDS for advanced orbiting systems. It consists of two sublayers:

- virtual channel link control (VCLC) sublayer
- virtual channel access (VCA) sublayer

The Global data link is designed as a Grade-2 service, i.e. transmission will be error controlled using Reed-Solomon coding.

The VCLC sublayer receives CCSDS path protocol data units (CP_PDU) from the network layer, whereas the VCA sublayer forwards the physical channel access protocol data unit (PCA_PDU) to the physical layer.

The data link layer provides by means of the VCLC sublayer the multiplexing service to its user, the network layer.

The VCLC sublayer provides the multiplexing service only. With each M-SDU the virtual channel is addressed by its VCDU-ID. Data from various packet channels addressing the same VC may be multiplexed into one M_PDU.

The VCLC sublayer uses the virtual channel access service of the VCA sublayer, the generated M_PDUs are forwarded as VCA_SDUs together with the VCDU_ID.

The structure of the M_PDU consists of a header (2 bytes) and a packet zone (882 bytes) into which the M_SDUs for the actual VC are inserted.

The components of the M_PDU header are defined as follows:

spare	for future use, set to all zero
first header pointer	contains a binary count P (0...2047) identifying the offset (in bytes) between the begin of the M_PDU packet zone and the first M_SDU header (i.e. M_SDU #k) therein. If the packet zone does not contain any M_SDU header at all (e.g. if a M_SDU spans over three or more M_PDUs) then P shall be set to all ones (i.e. 2047)

The M_PDU packet zone contains variable length M-SDUs, each of them being a CCSDS version-l packet. The first and th last packet in the M_PDU zone are not necessarily complete. The M_PDU packet zone may contain a part of a single M-SDU only.

In case that a partly generated M_PDU cannot be completed since no more M_SDU is available for the related virtual channel, a fill packet can be generated to complete the M_PDU.

The VCA sublayer provides the virtual channel access service and the insert service only. The VCA sublayer generates the physical channel access protocol data unit (PCA_PDU)

The virtual channel procedures are functions required to generate virtual channel data units (VCDUs) from VCA_SDUs and vice versa. One of the channel access procedures is to handle Reed-Solomon check symbols. A VCDU with attached check symbols is called coded virtual channel data unit (CVCDU).

The elements of the CVCDU are as follows:

VCDU primary header	contains a six byte header structure.
VCDU insert zone	contains one IN-SDU having a length of 2 bytes, set to 0000
VCDU data unit zone	contains one VCA-SDU in case of a valid VCDU or all zeros in case of a fill VCDU, the size of this field is 884 bytes.
Reed-Solomon check symbols	contain Reed-Solomon code (255,223) encoded check symbols, calculated over the PCDU primary header and the VCDU data unit zone.

The VCDU primary header consist of the following elements:

version number	set to 1 specifying version-2 CCSDS structure
VCDU-ID	virtual channel data unit identifier as specified by higher layers consisting of spacecraft identifier and virtual channel identifier, set to 63 for fill VCDUs.
VCDU counter	sequential count (modulo 16777216) of VCDUs on each virtual channel
signalling field	set to 0 specifying realtime VCDUs

The insert service data unit (IN_SDU) is a fixed length data structure having a length of 16 bits (2 bytes). IN_SDU shall be set to all zeros. It is used for encryption purpose on the direct broadcast services. There is no encryption of the recorded data link.

Each commutated sequence of CVCDUs is converted into a sequence of channel access data units (CADUs). For this purpose each CVDU is randomized first and preceded by a synchronisation marker then. Randomisation is performed by multiplying all 8160 bits of the CVCDU with a statically defined pseudo-noise pattern. The pseudo-noise sequence is generated by means of the following polynomial:
$h(x) = x^8 + x' + x^5 + x' + 1$.

This sequence repeats after 255 bits and the sequence generator has to be started from an all-ones state. The resulting PN pattern begins with (hexadecimal) FF480EC09A...

The synchronisation marker is defined to be 1ACFFC1D (in hexadecimal) (tbd) which describes a 32 bit pattern to precede each CVCDU.

Each CADU has a length of 8192 bits.

The platform will prepare an auxiliary data VCDU containing Housekeeping data (512 bytes) and ancillary data (128 bytes) - and fill data- to be sent every second (tbc).

C2.5.4 Physical Layer

carrier frequency band	7.75 - 7.90 (TBC depending on the meteorological allocation during WARC 97)
carrier frequency	7.8 GHz TBC
polarisation	RHCP
axial ratio	TBD
EIRP	such to insure a constant flux at the G/S during visibility period; to be optimised taking into account coding and bit rate
maximum PFD	-150 $dBW/m^2 \bullet 4KHz$ for $0<\delta<5$ -150 + $0.5 \bullet (\delta-5)$ $dBW/m^2 \bullet 4KHz$ for $5<\delta<25$ -140 $dBW/m^2 \bullet 4KHz$ for $25<\delta<90$
modulation	hard keyed QPSK or DEQPSK
data rate	50 Mbit/s (TBD)
coding	Reed-Solomon or Reed -Solomon concatenated with convolutional (Viterbi 7, 1/2)

required data quality (Frame loss probability)	10^{-6}
on-board technological loss	1 dB
visibility period (Kiruna and Fairbanks/Wallops)	> 539 s for 5 deg. elevation angle
visibility period (Svalbard)	> 387 s for 5 deg. elevation angle

The spectral mask for the X-Band signal is TBD. Radio frequency occupation shall be minimised

C2.5.5 Ground Segment

The following G/S characteristic shall be considered:

G/S figure of merit	32 dB/K at 5 deg. elevation
pointing loss	TBD
axial ratio	1 dB
total technological degradation in the down link	2.5 dB

The attenuation due to atmospheric phenomena, i.e. rain, clouds, gas, scintillation, which is not exceeded for 99,9% of the time shall be considered.
For the G/S of Kiruna, the foreseen attenuation is reported here below:

Satellite elevation (deg.)	5	10	20	40	60	90
Attenuation (dB)	2.5	TBD	TBD	TBD	TBD	TBD

C2.6 HRPT (UHF)

While the exact definition of the BRPT is contained in AD01 (ESA/EUMETSAT joint document, not issued yet), the requirements on the physical link are reported here for completeness.

C2.6.1 Physical Layer

slant range	up to 3000 km
carrier frequency band	1670 - 1710 MHz
centre frequency	1707 MHZ
centre frequency (back up)	1701 MHz.
carrier uncertainty	$\pm 2 \bullet 10^{-5}$
bandwidth	4.5 MHz
polarisation	RHCP
axial ratio	4.5 dB
EIRP	such to insure a constant flux at the G/S during visibility period, compatible with link budget
maximum PFD	-154 $dBW/m^2 \bullet 4KHz$ for $0<\delta<5$ -154 + $0.5 \bullet (\delta-5)$ $dBW/m^2 \bullet 4KHz$ for $5<\delta<25$ -144 $dBW/m^2 \bullet 4KHz$ for $25<\delta<90$ -133 $dBW/m^2 \bullet 1.5$ MHz, (from 1670 to 1700 MHz)
modulation	UQPSK NRZ-L
data rate I channel	1,500.0 Kbit/s
data rate Q channel	2,000.0 Kbit/s
I/Q power ratio	3/4
coding	Reed-Solomon
encryption	according to AD01
required data quality (Frame loss probability)	10^{-6}
on-board technological loss	1 dB

The spectral mask for the HRPT signal is TBD. Radio frequency occupation shall be minimised

C2.6.2 Ground Segment

The following characteristics for a Ground Station located anywhere in the world shall be considered

G/S figure of merit	6.5 dB/K at 5 deg. elevation
pointing loss	0.5 dB
axial ratio	4.5
total technological degradation in the down link	2.0 dB TBC

Atmospheric and ionospheric effect on the transmission channel shall be considered. These vary with the G/S location, the relative position of the S/C and the service availability. Ionospheric effects have also yearly, seasonal, daily and hourly variations.
The link degradation due to atmospheric and ionospheric attenuation, as well as link impairments due to group and time delay, dispersion and ionospheric scintillation, shall be reflected in the link budget considering a link availability of 99.8% of the average year.

C2.7 LRPT (VHF)

While the exact definition of the LRPT is contained in AD01 (ESA/EUMETSAT joint document, not issued yet), the requirements on the physical link are reported here for completeness.

C2.7.1 Physical Layer

slant range	up to 3000 km
carrier frequency band	137 - 138 MHz
centre frequency	137.1 MHz
centre frequency (back up)	137.9 MHZ.
carrier uncertainty	$\pm 2 \cdot 10^{-5}$
bandwidth	150 kHz
polarisation	RHCP
axial ratio	4.5 dB
EIRP	compatible with link budget
modulation	BPSK NRZ-L
data rate	72 Kbit/s
coding	Reed-Solomon
encryption	according to AD01
required data quality (Frame loss probability)	10^{-6}
on-board technological loss	1 dB

The spectral mask for the LRPT signal is TBD. Radio frequency occupation shall be minimised

C2.7.2 Ground Segment

The following characteristics for a Ground Station located anywhere in the world shall be considered

G/S figure of merit	-22.4 dB/K for elevation greater than 5 deg. -30.4 dB/K for elevation greater than 13 deg.
pointing loss	0 dB
axial ratio	TBD
total technological	

degradation
in the down link 2.0 dB TBC

Ionospheric effects on the transmission channel shall be considered. These vary with the G/S location, the relative position of the S/C, the service availability and they have also yearly, seasonal, daily and hourly variations. The link degradation due to ionospheric attenuation, as well as link impairments due to group and time delay, dispersion and ionospheric scintillation, shall be reflected in the link budget considering a link availability of **99.8% of** the average year.

C3. TELECOMMANDING

C3.1 GENERAL

The **METOP** satellite operational commanding requirements shall be compliant with AD02.

C3.2 INSTRUMENTS SPECIFIC OPERATION REQUIREMENTS

Generally, coefficients for on-board radiometric correction shall be determined on ground and **uplinked** to the satellite by telecommand.

Met instrument

Instrument	operations during non-operational modes	Software unload	Specific operational requirements	Volume of operation per orbit/per day in nominal
AVHRR	(1)	NA (tbc)	decontamination	day/night commanding
HIRS	(2)	no	tbd	calibration commanding
MHS	(3)	facility available	tbd	none
AMSU-A	(4)	no	tbd	none
SEM	(5)	no	no tbc	none
DCS	(6)	no	no	none
S&R	(7)	no	no	none
VIRSR	(8)	tbd	self calibrated	tbd
IASI	(9)	yes	decontamination	tbd

(1) AVHRR operations during non operational modes (motor running during LEOP or safe modes)

(2-8) tbd.

(9) **IASI** shall require software unloads; coefficient for **onboard** radiometric correction shall be determined on ground and **uplinked** to the satellite by telecommand.

The number of instruments parameters are given below.

Instrument	number of commands	TM measurement points (analog / digital)
AVHRR	30	22/15
HIRS	26	16 / 14
MHS	35	59 (delivers housekeeping packets : size of 80 bytes)
AMSU A1 AMSU A2	14 13	27 / 11 15 / 10
SEM	13	13 / 9
DCS	23	10 / 13
S&R	21	31 / 18
VIRSR	tbd	tbd
IASI	tbd	tbd

Other instruments

Instrument	operations during non-operational modes	Software unload	Specific operation requirements	Volume of operation per orbit/per day
ASCAT	no	tbd	tbd	tbd
MIMR	no	tbd	tbd	tbd
OMI	no	tbd	tbd	tbd
ScaRaB	no	tbd	tbd	tbd

Instrument	number of commands	number of measurements points
ASCAT	tbd	tbd
MIMR	tbd	tbd
AATSR	tbd	tbd
OMI	tbd	tbd
ScaRab	tbd	tbd

C4. MONITORING

The METOP satellite operational monitoring requirements shall be compliant with AD02.

C5. OPERATIONS

C5.1 **METOP** MISSION PHASES DESCRIPTION

During its lifetime in orbit, the **METOP** operates during a number of missions phases defined in AD02.

The ground stations used for LEOP are belonging to the ESA Network **(tbc)** complemented by the US network; they are Kiruna, Kourou, Malindi, Perth, Maspalomas, Villafranca and Fairbanks **(tbc)** Santiago **(tbc)**. Stations characteristic are further described in RD12.

In the Routine Phase, **METOP** will be controlled from Kiruna Ground station (tbc) which will ensure ranging and doppler analysis for orbit prediction and restitution.

A typical nominal operation sequence shall be applied during a pass over Kiruna.

1. carrier acquisition and tracking
2. **synchronise** on S-Band format
3. receive and monitor several real time formats, evaluate spacecraft parameters, and correlate **onboard** to ground time
4. send command to request satellite report formats
5. send commands to reset history areas
6. send payload operation **timeline** and software loads (as MCMD)
7. perform S-Band ranging.

During this phase, the ground segment shall perform:

- Orbit computation.
- Orbit prediction for the local users and for the generation of commands related to orbit control (in plane and out of plane manoeuvres, low drag / air drag monitoring node time, inclination drift, eccentricity control, ground track control . ..)

C5.2 SATELLITE CONTROL

The satellite control aspects are defined in AD02.

STATEMENT OF WORK AND TECHNICAL REQUIREMENTS

ANNEX D

MANAGEMENT REQUIREMENTS AND TASKS

Prepared by: METOP Team

Checked by: R. van Rees

Approved by: P.G. Edwards 29/9/94

METOP Project Manager
Earth Observation Projects Department

CONTENTS LIST

D1 MANAGEMENT REOUIREMENTS & TASKS

D1.l SCOPE AND APPLICABILITY

This section stipulates the management requirements to be followed by the Contractor during the Phase B. The objective is to ensure adequate interfacing with the Agency, so that plans and other established baselines are followed and updated and so that sufficient visibility is provided during the Contract execution. These requirements cover the relationship and interfaces between the participants in the project, the communication channels and the requirements for technical, documentation and schedule control.

The Contractor must ensure that his subcontractors comply as necessary with these requirements in order that the Contractor shall fulfil his commitments to the Agency. The management requirements applicable to Phase C/D shall be issued by the Agency as part of the Phase C/D ITT.

D1.2 GENERAL MANAGEMENT REQUIREMENTS

The Contractor shall establish a Project Management Office which shall monitor all technical and commercial activities of the Contractor's effort and provide the direction necessary to accomplish the project.

The Contractor shall implement and operate a Project Management System so that all project requirements shall be met in a timely and cost effective manner. In particular the system shall provide visibility of the total project effort and provide means for monitoring the execution of all tasks. It shall be capable of detecting potential, as well as existing problems and to provide possible solutions such that appropriate corrective action can be taken.

During the Phase B the Contractor shall reissue the Phase B Management Plan for Phase C/D.

D1.3 ORGANISATION & INTERFACE

D1.3.1 Responsible Officers of the Agency

The Agency's Project Manager
is the primary representative of the Agency concerning the execution of the project and is responsible for all pertinent management functions. He shall ensure the performance of the Agency's undertaking and liaise with all parties involved in the project. He has full authority to carry out these functions.

The Agency's Contract's Officer
as representative of the Contracts Department is responsible for all legal and contractual aspects of the Contract. He assists and advises the Project Manager in all matters having legal or contractual implications during Contract negotiations and Contract execution.

Authority *for* Signature
Formal communications concerning the project, which are not signed by the Agency's Project Manager (or duly appointed Representative) and for contractual matters by the Contracts Officer, shall not be binding on the Agency.

D1.3.2 Responsible Officers of the Contractor

The Contractor's Project Manager
is responsible for the execution of the Contractor's tasks under the Contract. The Contractor shall not initiate the replacement of the Project Manager without prior approval of the Agency.

The Contractor's *Contract's* Officer
is responsible for the contractual and legal aspects of the project in conjunction with the Project Manager. The Contractor shall not initiate the replacement of the Contracts Officer without prior approval of the Agency.

Authority *for Signature*
Formal communications raised by the Contractor concerning the project and not signed by the Contractor's duly appointed representatives shall not be considered by the Agency as binding on the Contractor.

D1.3.3 Delegation of Authority

Responsibilities described above may be delegated to other designated officers. Such delegation shall be notified in writing to the Contractor or to the Agency on a case by case basis.

D1.3.4 Communication Channels

Contact between the Agency on the one hand, and the Contractor and his Industrial Group on the other, shall be channelled as outlined in the contract. Failure to comply with this requirement shall render the Contractor responsible for any consequences.

Formal Communica tions
are defined as the exchange of information which affects the technical standards, deliverables, time schedule, costs or any other relevant aspects of the project that impacts the contract.

D1.3.5 Correspondence

Correspondence shall be addressed as stipulated in the Contract. Urgent correspondence shall be transmitted by means of TELEFAX. Note that the Agency uses "Kalle-Infotec" (International Standard LEVEL 3) as telefax standard. The deployment of compatible equipment is required from the Contractor.

All project correspondence shall have a unified reference system to be implemented by all members of the industrial consortium. Unless otherwise proposed by the Contractor, the reference will take the form VV-XXX-YYY/ZZ where W is the Project Identifier (e.g. MO for METOP), XXX is the Company Identifier (e.g. ESA), YYYY is a sequential number (e.g. 0001) and ZZ is the year (e.g.95).

D1.3.6 Language

Apart from the Contractors' and Sub-contractors' internal working documents, all other METOP project documentation shall be written in English. All deliverable documents listed in the DRL shall be in English.

D1.3.7 Contractor's Organisation

The Contractor shall nominate a project team and convey to the Agency the names of his key personnel. Formal communications as defined above will take place between the respective responsible officers.

D1.4 TECHNICAL MONITORING & CONTROL

The Agency shall monitor the Contractor's performance and exercise technical control over the Contractor. This will be done in particular by holding progress meetings and milestone reviews, as defined below, and checking and analyzing documentation.

D1.4.1 Milestone Reviews & Meeting6

As part of the technical and cost monitoring process for all projects, the Agency requires that formal Milestone Reviews be performed at key stages of the work. Each review will determine the compatibility of the existing technical status with originally-specified requirements, and will also examine plans, specifications and procedures for future work in order to provide confidence that the specified requirements will be met within the defined cost envelope.

Review packages shall be available at ESA. The documents which are part of the review package are defined in the DRL. It is the responsibility of the Contractor to prepare for, support and provide facilities for such reviews, when held at the Contractor's premises. In particular, the Contractor shall provide meeting rooms and logistic support, technical presentations of status, an adequate staff support to permit all questions raised during the review to be fully discussed.

Milestone Reviews shall be held at the times and places defined in section 2.5 of the S.O.W. During Phase B, in addition to the kick-off meetings and reviews, progress meetings on management and technical aspects shall be held at six weekly intervals.

In addition, the Contractor shall arrange, as appropriate, progress meetings with his major sub-contractors. The timing of these meetings shall be related to the system level progress meetings. The Agency shall be advised of, and have the right to attend, these meetings.

D1.4.2 Audits

At any time, the Agency has the right to conduct special audits as stipulated in the Contract. In particular, the Agency may conduct progress audits at the premises of the Contractor or any Contractor or supplier to assess the progress and the schedule status.

ESA may perform Product Assurance Audits during Phase B.

D1.4.3 Minutes

If not otherwise specifically requested by the Agency's Representative, the Contractor shall write the minutes for all meetings and reviews. At the meetings and reviews the results of and the actions arising from each meeting and review shall be briefly recorded, signed by the Authorised Representatives of each party and distributed. The signature of such minutes indicates solely that the wording is correct and properly reflects the outcome. Such signature shall not be construed as a contractual agreement. Any matter having contractual implications shall be referred in writing to the Agency's Project Manager and Contracts Officer for review and approval.

D1.4.4 Periodic Progress Reports

6 weekly progress reports shall be made available at ESTEC.
The number of copies is defined in the DRL.

D1.4.5 Meeting Calendar

The Contractor will maintain, and issue at 1 monthly intervals a meeting calendar showing date, subject, location and planned participation of all project meetings in which the Contractor is involved.

D1.5 INFORMATION MANAGEMENT

The Contractor shall ensure the generation, timely delivery and maintenance of all documentation as specified in the Documentation Requirements List.
In addition to the DRL, the Contractor shall make available, on request, a copy of any project-relevant document which has been generated.

D1.5.1 Documentation

The Contractor shall operate a project-centralised documentation system to fulfil the information requirements of the project.
The documentation system shall be capable of providing up-to-date information on all aspects of the project, at all times. Project participants shall have quick and easy access to this information. The documentation system shall, in particular, serve as a reference for technical interfaces and for introducing and executing all project modifications. The project documentation centre shall be equipped with effective and reliable means for the reproduction and transmission of documents. All documents shall be easy to handle and be such as to provide rapid and comprehensive information on the project.
The Contractor shall grant access to the documents if so required by the Agency.

a) Documentation Identification and Referencing

The Contractor shall ensure documentation consistency. The Contractor shall ascertain that all project documents carry a heading with the name of the project followed by the document description and an identification code. The identification code will be unified with all members of the METOP industrial consortium. Unless otherwise proposed by the Contractor, the idenfication code will take the form W-W-XXX-W-ZZZZ where W is the Project Identifier (e.g. MO for METOP), W is the document type (e.g. TN for Technical Note), XXX is the Company Identifier (e.g. ESA), YY is the subject area (e.g. SA for Satellite) and ZZZZ is a sequential number (e.g. 0001).

NOTE: The Contractor in establishing the documentation identification and referencing system, shall disresard the DRD references in the DRL.

b) Format and Distribution

All documents shall be DIN A4 sired and shall be suitable for accommodation in loose leaf binders (e.g. ring binders). If diagrams, tables and other large documents are wider than A4 sire they shall conform as far as feasible to the standard DIN formats and be folded to A4 size.

Class A documents (approval required by ESA) shall have an identified place for the ESA Project Manager's signature. Each page of every document shall be individually identifiable with reference, page number, revision status and date of issue, viz.:

- .Ref.:
- .Page:
- .Issue/Revision:
- .Date:

This information shall be typed systematically on the upper right or left hand corner of each page of text and diagram, such that the information is always opposite the binding fixture, i.e. visible at the outside.
Where appropriate, introductory pages to a document shall include the following items and have numbering different from that used for the proper text of the document.

.Front cover sheet	(i)
.Distribution list	(ii)
.Change Record sheet	(iii)
.Table of Contents	(iv)

Pages of proper text shall always begin at I.
Documents submitted to the Agency shall be of adequate quality to withstand the expected wear and tear but shall not be heavier than absolutely necessary. The contrast between printed information and blank page space shall be sufficient to allow further photostatic reproduction for distribution within the Agency.

c) Revision and Maintenance of Documents

ESA-generated Documents
If an ESA document is updated during the contract it will be either by revision or by a new issue. Revisions will be made for minor additions, deletions or changes of information. Revisions may be effected by mere transmission of instructions, which shall lead to a hand-correction of the established information or they may be effected by re-transmission of the corrected sheet. Revisions, designated by letters A, B, C etc, will apply to the page level, and the essential changes will be suitably identified by marks on the pages concerned. Revision sheets will be sent to the recipients of the original document as specified on the distribution list. New issues or re-issues will be made when major changes in the scope or the text have evolved. Re-issues of a document will be designated by numbers (1, 2 etc.)

Contractor-generated Documents
The above procedure applies also to the Contractor generated documents.

d) Classification of Documentation

Documents shall be classified according to the following categories:

"A" Approval
These documents shall be approved by the Contractor and ESA prior to their implementation. After approval these documents are contractually binding.

"R" Review
These documents shall be approved by the Contractor only, prior to their implementation. Implementation can start as soon as errors and inconsistencies incurring *ESA* disapproval are corrected by the Contractor. Failure to comply with these requirements shall be at the Contractor's risk. In any event the Contractor shall notify the Agency of his decision before implementation.

"I" Information
Self explanatory.

Documents classified "A" & "R" shall be processed as follows:

- Submission to ESA, after Contractor's approval, prior to their implementation.
- Evaluation by ESA, who will comment on them and notify the Contractor within ten working days from the date of receipt by the ESA Project Office.
- Return to the Contractor with approval evidence for "A" documents or with re-submission instruction in case of disapproval by ESA.

It is understood that the above indicative classification will only enter into force <u>after</u> completion of phase B.

e) <u>Documentation Status</u>

The Contractor shall maintain documentation acquisition lists of all documents generated, or received, indicating their present status.
The Contractor shall, on a monthly basis, supply the Agency with an updated list of all formal and working documents produced during the preceding month.

DI.5.2 **Terms & Definition, Acronyms & Abbreviations**

The Contractor shall maintain an updated list of terms and definitions, and of acronyms and abbreviations based on those provided in Annex A.

DI.5.3 Project **Directory**

At the Phase B Kick-Off meeting the Contractor shall provide the Agency with a project directory containing the following information for each participating Firm and Establishment:

- Telephone numbers
- Telefax
- Electronic mailing addresses.

For all key personnel of the Contractor & associated sub-contractors:

- Names
- individual telephone numbers
- Individual telefax numbers (if appropriate)
- Individual electronic mailing addresses.

The Contractor shall keep the project directory up-to-date and send revisions as necessary to the Agency.

D1.6 SCHEDULE CONTROL

D1.6.1 Schedule & Progreee Control Procedures

The requirements of PSS-32, Section 4 shall apply with the following amendments:

- Maintenance of the Phase B networks is not required.
- The six weekly schedule reporting (as part of the progress report) shall be based on milestones and bar charts. In special circumstances the Agency may require an update of the Phase B planning documents and a bi-weekly schedule status report.
- The Contractor shall maintain up-to-date these milestones and bar charts, preferably in A4 format for easy transmission, compliant with the work breakdown structure (WBS) and associated workpackage descriptions. At least one bar chart has to be prepared for each Level 2 element of the WBS and for Level 3, if under WBS elements "Payload".

Revision of above documents shall be submitted, if applicable, with the monthly progress report.

D1.6.2 Action Item Control

General

The aim of the Action Item control is to provide an effective means for ensuring that project actions are initiated, recorded, performed and monitored properly.
Project actions will normally originate from reviews and meetings held between the Agency and the Contractor.

Action *Initiation* Procedure

Actions initiated during meetings and reviews shall be recorded in the minutes. Each action shall be entered in the Action Item Record. The Action Item Record shall identify the venue and the date at which the action item was initiated. Each action item shall show in the description column the following information:

- Brief title of action item
- Concise description

In addition, the following information shall be given:

- Closing date
- Actionee
- Originator

When a main meeting is divided into sub-groups, the same procedure shall be adopted by the Minutes Secretaries appointed to the sub-groups. The main meeting or sub-group meeting shall not be considered closed until each page of the Action Item Record has been signed by the Authorised Representative of the parties involved, and each party is in possession of a copy.

Responsibility for Action & Action Item Monitoring

Each Actionee shall report the results of his action(s) to the Originator. The report shall contain the status, e.g. newly approved/rejected/late/new completion date or completed/description of the result. A number shall be assigned by the Contractor to each item. The Contractor shall submit a report listing the action item status, with the monthly progress report.

D1.7 PROCUREMENT/PROPERTY CONTROL

D1.7.1 Procurement Control for Critical Items

Critical items are hard- or software items which are intended to be procured and bear some risk with regard to delivery, schedule, qualification status, safety, or any other criteria which, if not properly met, would jeopardise the proper execution of the following project phases.

D1.7.2 Property Control

Property control is the method for handling, storing, accounting and disposing of property items of the Agency.
The Contractor shall ensure property control throughout the Industrial Group involved in the performance of the Contract, including any other third party who acts on his behalf or to whom he entrusts Agency property.
Property control shall be performed in accordance with the requirements stipulated in the contract and, if appropriate, the Property Control Plan submitted in the tender as modified and/or approved by the Agency.
The Contractor shall not change the property control procedures without the formal agreement of the Agency.

D1.8 CONFIGURATION CONTROL

The tasks related to configuration control are defined in 4.7 of the SOW.

D1.9 CHANGE CONTROL PROCEDURES

For requirements covering Contract Change Procedures, refer to Appendix 3 of the contract.

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STATEMENT OF WORK AND TECHNICAL REQUIREMENTS

ANNEX E

DOCUMENTS REQUIREMENTS LIST

(DRL)

Prepared by: METOP Team

Checked by: J. Bosma 30. 9. 94

Approved by: P.G. Edwards 29. 9. 94

METOP Project Manager
Earth Observation Projects Department

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	PROJECT MANAGEMENT **(PM)**	**KO**	PR	SRR	CAT	COPIES	**REMARKS**
PM-l	Project Managem. Plan		1	2	A	10	Re-issued for **PhaseC/D**
PM-2	Progress Report				I	5	6 weekly
PM-3	Minutes of Meetings				I	5	As required
?M-4	Prime Contractor's ITT for Phase B sub-contractors				R	10	For those **sub-** contracts not part of the original Phase B offer
PM-5	Prime Contractor's ITT for Phase C/D to Sub-Contr.			1	R	10	
PM-6	Parametric Cost Analysis for Phase C/D			1	I	10	
PM-7	Cost Reports				R	5	**As** defined in PMP
PM-8	Schedule and **Bar-** Charts				R	5	As defined in PMP
PM-9	Change Notices				A/R	5	As defined in PMP
PM-10	Monthly Meeting Plan				I	5	Monthly

Key:
PF = Preliminary Review
SRR = System Requirements Review

A => Agency Approval Required
R => For Agency Review
I => For Information Only

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	SATELLITE SYSTEM	KO	PR	SRR	CAT	COPIES	REMARKS
SY-1	Sat. System Techn. Description		2	3	I	10	Issue 1, Part of Phase B Proposal
SY-2	Sat. System Requirement Spec.		1	2	A	10	
SY-3	Sat. System Spec. and Plan Tree		1	2	A	10	
SY-4	Sat. System Budgets Document		1	2	R	10	
SY-5	Sat. System Analysis and Trade-offs Summary Rep.		1	2	I	10	
SY-6	In-Flight Sat. System Performance Verification Plan			1	A	10	
SY-7	Sat. System Design and Development Plan			1	A	10	
SY-8	Sat. System Calibration Plan			1	A	10	
SY-9	Supporting Analyses and Studies Docs.				I	10	
SY-10	Sat./Ground Segment I/F Definition			1	A	10	Complemented/or integrated into ESA/ EDMETSAT Doc.
SY-11	Sat. Environm. Design and Test Reguir. Spec.			1	A	10	
SY-12	Sat. EMC/RFC Analysis		1	2	I	10	

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

RD EF.	SATELLITE SYSTEM	KO	PR	SRR	CAT	COPIES	REMARKS
Y-13	Sat. EMC/RFC Control Plan			1	R	10	
Y- 14	Sat. EMC/RFC and Power Requirements Spec.			1	A	10	
Y-15	Sat. Requir. on Ariane Launcher System			1	A	10	Including launch facilities interfaces
Y-16	Sat. Software Engineering Standards			1	A	10	
Y-17	Sat. Software, Design, Development and Verification Plan			1	A	10	
Y-18	Sat./GSE I/F Spec.			1	R	10	
Y-19	Sat./Test Facility I/F Specs.			1	R	10	
Y-20	Platform/Payload I/F Spec.		1	2	A	10	
IY-21	Sat. Mech./Ther. Design Requir.			1	A	10	
;A-22	Sat. Electrical Design Requir.			1	A	10	
;Y-23	Sat. Cleanliness Design Requir.			1	A	10	
;Y-24	Sat. Safety Design Requir.			1	A	10	
SY-25	Flight Operations Manual			1	R	10	Outline only for Phase B
SY-26	Satellite Sub-Systems Interface Spec.			1	R	10	
SY-27	Frequency Plan			1	R	10	
SY-28	Command and Control Interface Specification			1	A	10	

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	PLATFORM	KO	PR	SRR	CAT	COPIES	REMARKS
PF-1	Platform Technical Description		1	2	I	10	
PF-2	Platform Design Specifications		1	2	R	10	
PF-3	Platform Sub-System Design Spec.			1	I	10	According to Spec. tree proposed by Contractor
PF-4	Platform Equipment Spec.			1	I	10	According to Spec. tree proposed by Contractor
PF-5	Platform Verification & Test Plan			1	R	10	
PF-6	Platform Design and Development Plan			1	R	10	

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	PAYLOAD SUPPORT SUB-SYSTEM	KO	PR	SRR	CAT	COPIES	REMARKS
SS-1	Payload Support Sub-System Tech. Descript.		1	2	I	10	
SS-2	Payload Support Sub-System Design Spec.		1	2	R	10	
SS-3	Payload Support Sub-System Equipment Spec.			1	I	10	According to Spec. tree proposed by Contractor
SS-4	Payload Test & Verification Plan			1	R	10	
SS-5	Design and Development Plan			1	R	10	<u>Note</u>: Set of docs (SS-1 to SS-5) required for the following proposed Payload or other Support Sub-systems: - Structure - Thermal Control - Avionics - Electrical Power

The DRD Ref. "SS" will be replaced by the sub-system codes for the individual sub-systems e.g. Structure, Thermal Control etc.

Satellite level sub-systems not covered under platform shall be included.

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	ADVANCED SCATTEROMETER	KO	PR	SRR	CAT	COPIES	REMARKS
AS-1	ASCAT Instrument Technical Description		1	2	I	10	
AS-2	ASCAT Instrument Design and Performance Spec.			2	R	10	
AS-3	ASCAT Instrument Sub-system/Equipment Spec.			1	I	10	According to Spec. tree proposed by Contractor
AS-4	ASCAT Instrument Verification, Test, Calibration and Characterisation Plan			1	I	10	
AS-5	ASCAT Instrument Design and Development Plan			1	R	10	
AS-6	Instrument ICD			1	R	10	

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	MULTI-FREQUENCY IMAGE MICROWAVE RADIOMETER	KO	PR	SRR	CAT	COPIES	REMARKS
MI-1	MIMR Instrument Technical Description		1	2	I	10	
MI-2	MIMR Instrument Design and Performance Spec.			2	R	10	
MI-3	MIMR Instrument Sub-System/Equipment Spec.			1	I	10	According to Spec. tree proposed by Contractor
MI-4	MIMR Instrument Verification, Test, Calibration and Characterisation Plan			1	I	10	
MI-5	MIMR Instrument Design and Development Plan			1	R	10	
MI-6	Instrument ICD			1	R	10	

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	CUSTOMER FURNISHED INSTRUMENTS	KO	PR	SRR	CAT	COPIES	REMARKS
CF-1	General Instrument Interface Control Doc. (GICD)		1	2	A	10	
CF-2	Interface Control Document (ICD)		1	2	A	10	for each CFI instrument

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	ASSEMBLY, INTEGRATION AND VERIFICATION (AIV)	KO	PR	SRR	CAT	COPIES	REMARKS
AV-1	Sat. System Verification Plan		1	2	A	10	
AV-2	Assembly, Integr. and Test (AIT) Plan			1	A	10	
AV-3	GSE Requirements Spec.			1	A	10	
AV-4	Facilities and Transporation Plan			1	R	10	
AV-5	Hardware/Software Matrix			1	A	10	Including CFE List
AV-6	EGSE Design Specs			1	R	10	Sub-system/ Instrument/ Sat.level.
AV-7	MGSE Design Specs			1	R	10	Sub-system/ Instrument/ Sat.level.
AV-8	EGSE Development Plan			1	R	10	
AV-9	MGSE Development Plan			1	R	10	
AV-10	Launch and Commissioning Phase Support Activities Plan			1	A	10	
AV-11	AIV/GSE Technical Notes				I	10	As necessary

PHASE B DOCUMENTATION REQUIREMENTS LIST (DRL)

DRD REF.	PRODUCT ASSURANCE	KO	PR	SRR	CAT	COPIES	REMARKS
P-1	PA and Safety Plan		1	2	A	10	
P-2	Reliability/Prediction Report		1	2	R	10	
P-3	FMECA Report		1	2	R	10	
P-4	Hazard Analysis			1	R	10	
P-5	EEE Component Control Plan		1	2	A	10	
P-6	Lists:					10	
P-6.1	- Critical Items		1	2	R		
P-6.2	- Long-lead Items (Components)		1	2	R		
P-6.3	- Declared Components			1	R		
P-6.4	- Declared Materials			1	R		
P-6.5	- Declared Processes			1	R		
P-6.6	- Preferred Parts List			1	R		
P-6.7	- Declared Mechanical Parts List			1	R		
P-7	Config. Management & Control Plan		1	2	A	10	
P-8	Contamination Control Plan			1	A	10	
P-9	PA Audit Plan			1	I/R	10	
P-9.1	PA Audit Reports			1	I/R	5	
P-10	Controlled Docs List			1	I	10	
P-11	PA Progress Reports				I	5	At each milestone, review, Progr. Mtg., as part of overall Prog. Report
P-12	Review Data Packages		X	X	R	10	
P-13	Fracture Control Plan			1	R	10	

STATEMENT OF WORK AND TECHNICAL REQUIREMENTS

ANNEX F

DOCUMENTS REQUIREMENTS DESCRIPTION

(DRD)

Prepared by: METOP Team

Checked by: J. Bosma 30. 9. 94

Approved by: P.G. Edwards 29/9/94

METOP Project Manager
Earth Observation Projects Department

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Project Management Plan
PM-1	

PURPOSE OF DOCUMENT

To define the management requirements for the work to be performed under the contract and the procedures to be applied by the Contractor to ensure that the objectives of the METOP programme are accomplished within the prescribed time schedule at minimum risk and cost.

CONTENTS

Project Management Plan, covering at least:

- basic project management requirements
- responsible officers and interfaces
- project management procedures, including
    - technical monitoring and control
    - schedule control and reporting
    - cost control and reporting
    - change control
    - property control

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Progress Reports
PM-2	

PURPOSE OF DOCUMENT

Monthly reporting of progress of all activities conducted within the METOP programme.

CONTENTS

Progress status, including at least:

- management activities, including action items status
- contractual aspects
- schedule update
- METOP system progress including instrument/sub-system progress for Prime/Sub-contractors
- EGSE status
- AIV status when applicable
- PA activities

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Minutes of Meetings
PM-3	

PURPOSE OF DOCUMENT

To summarise all action items, decisions, recommendations and statements made during METOP project meetings.

CONTENTS

Minutes of Meetings, including:

- cover sheet, recording subject of meeting, meeting place and date and agenda reference, list of participants
- minute summary sheets
- action items initiation sheet, covering action item title and description,
  due date, originator and actionee, completion status.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Minutes of Meetings
PM-3	

PURPOSE OF DOCUMENT

To summarise all action items, decisions, recommendations and statements made during METOP project meetings.

CONTENTS

Minutes of Meetings, including:

- cover sheet, recording subject of meeting, meeting place and date and agenda reference, list of participants
- minute summary sheets
- action items initiation sheet, covering action item title and description,
  due date, originator and actionee, completion status.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Prime ITT for Phase B to Subcontractors
PM-4	

PURPOSE OF DOCUMENT

To specify all work to be performed in Phase B by selected subcontractors.

CONTENTS

ITT to include:

- Statement of Work
- contract
- all requirement specifications.

For those sub-contracts not part of the original Phase B offer.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Prime ITT for Phase C/D to Subcontractors
PM-5	

PURPOSE OF DOCUMENT

To specify all work to be performed in Phase C/D by selected subcontractors.

CONTENTS

ITT to include:

- Statement of Work
- contract
- all requirement specifications.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Prime ITT for Phase B to Subcontractors
PM-4	

PURPOSE OF DOCUMENT

To specify all work to be performed in Phase B by selected subcontractors.

CONTENTS

ITT to include:

- Statement of Work
- contract
- all requirement specifications.

For those sub-contracts not part of the original Phase B offer.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Prime ITT for Phase C/D to Subcontractors
PM-5	

PURPOSE OF DOCUMENT

To specify all work to be performed in Phase C/D by selected subcontractors.

CONTENTS

ITT to include:

- Statement of Work
- contract
- all requirement specifications.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Parametric Cost Analysis for Phase C/D
PM-6	

PURPOSE OF DOCUMENT

To present a parametric cost analysis for Phase C/D METOP development, integration and test activities and the necessary set of flight spares.

CONTENTS

To include the above, plus the following options:

- launch operations/launch and early orbit phase/commissioning phase industrial support costs
- cost of recurrent satellite flight models order at Phase C/D kick-off or ordered separately at a later date.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Cost Reports
PM-7	

PURPOSE OF DOCUMENT

As defined in PMP.

CONTENTS

As defined in PMP.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Schedule and Bar Charts
PM-8	

PURPOSE OF DOCUMENT

As defined in PMP.

CONTENTS

As defined in PMP.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Change Notices
PM-9	

PURPOSE OF DOCUMENT

As defined in PMP.

CONTENTS

As defined in PMP.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Monthly Meeting Plan
PM-10	

PURPOSE OF DOCUMENT

As defined in PMP.

CONTENTS

As defined in PMP.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite System Technical Description
SY-1	

PURPOSE OF DOCUMENT

To provide a comprehensive technical description of the overall METOP satellite system.

CONTENTS

Technical description, to include:

- introduction,
- mission, performances and operations overview
- satellite design concepts
- baseline satellite description
- satellite system budgets
- programmatics

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite System Requirements Specification
SY-2	

PURPOSE OF DOCUMENT

To define the overall requirements of the METOP system in terms of the primary performance requirements, its operational requirements, design and test requirements of the fully integrated spacecraft, and interface requirements between the spacecraft and ground segment and between the spacecraft and launcher.

CONTENTS

System specification in terms of:

- description of mission requirements
- description of METOP system
- system performance requirements
- derived performance specification for each instrument
- system operation requirements
- system design requirement
- identification of all system interfaces
- system test and verification

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite System Specification and Plan Tree
SY-3	

PURPOSE OF DOCUMENT

To define, in block diagram form, all specifications and plans for the METOP system from satellite system level down to equipment level.

CONTENTS

Specification and Plan tree(s) covering:

- all satellite system requirements (including satellite to ground segment I/F and system simulators, if applicable)
- satellite requirement specs. (incl. GSE requirements, satellite to launcher requirements, software and environmental requirements, PA)
- all sub-system and instrument/equipment level requirements/design specifications
- all Plans (test, design/development, calibration/characterisation)

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite System Budgets Document
SY-4	

PURPOSE OF DOCUMENT

To provide a comprehensive source of reference for all METOP satellite system budgets.

CONTENTS

All satellite system budgets, including:

- satellite reference axes,
- mass and mass properties,
- power and thermal budgets,
- energy
- all RF link budgets
- TM/TC and data bus exchange budgets
- software and memory budgets
- on-board propellant
- system performance, data quality, reliability and availability
- frequency plan.
- TM/TC budgets
- synchronisation and datation budget
- EMC/EMI budget
- attitude budget
- alignment budget
- data quality budget (for ASCAT and MIMR for each physical measurement including geometrical, spatial and radiometric quality
- calibration budget and error budget
- radiation budget
- pyrotechnics budget
- vibration modes of satellite, platform and payload.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite System Analysis and Trade-Off Summary Report
SY-5	

PURPOSE OF DOCUMENT

To provide a list of all the major analyses and trade-offs performed in the course of the METOP system design together with a summary of the results and conclusions.

CONTENTS

Summary report, to include:

- trade-off approach
- general trade-off criteria
- summary of system trade-offs
- results and conclusions.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE In-Flight Satellite System Performance Verification Plan
SY-6	

PURPOSE OF DOCUMENT

To define all activities related to the full verification of the in-orbit METOP satellite system.

CONTENTS

In-flight performance verification, including:

- satellite activation and stabilisation
- satellite testing, including functional checks of all modes and measurement performance
- instrument calibration activities
- verification of overall system performance

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite System Design and Development Plan
SY-7	

PURPOSE OF DOCUMENT

To define the overall METOP satellite system design and development activities.

CONTENTS

Design and development plan, to include:

- system definition
- system design and development flow, model philosophy
- description of system level activities
- schedule, including major milestones and reviews.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite System Calibration Plan
SY-8	

PURPOSE OF DOCUMENT

To define all METOP satellite system and instrument calibration activities, both on-ground and in orbit.

CONTENTS

Plan of all calibration activities, including:

- system calibration definition
- on-ground calibration activities
- in-orbit activities
- calibration activities flow
- definition of calibration facilities required
- required frequency of calibration.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Supporting Analyses and Studies Documentation
SY-9	

PURPOSE OF DOCUMENT

All additional analyses and studies performed by the Contractor to support the proposed METOP system design.

CONTENTS

As necessary.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE
SY-10	Satellite to Ground Segment Interface Definition

PURPOSE OF DOCUMENT

To define the interfaces between the METOP satellites and all ground stations.

CONTENTS

Satellite to Ground Segment I/F definition, including:

- METOP system overview
- salient satellite and orbit requirements
- data formats and rates, coding scheme and modulation, encryption
- reference profile assumptions
- TELECOMS
  - frequency
  - link budget
  - data formats
  - TM/TC formats
  - auxiliary information
- ground station front-end requirements.
- ranging requirements
- computerised data base structure

This document complements, and may be integrated into, the equivalent ESA/EUMETSAT document.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Environmental Design and Test Requirements Specification
SY-11	

PURPOSE OF DOCUMENT

To define the natural and induced environment that the METOP satellites and their component parts shall be able to withstand in all phases of transportation, handling, storage, pre-launch, launch and ascent and in-orbit.

To specify the levels and profiles of mechanical and thermal environmental tests to demonstrate qualification and acceptance of the METOP hardware at equipment, sub-system/instrument payload, platform and satellite levels.

CONTENTS

Environmental Design and Test Requirements in terms of:

- general test requirements
- qualification and acceptance environmental test specs (for sinus/random, acoustic, TV, etc.) and test methods at

  a) equipment level
  b) sub-system/instrument level
  c) payload/platform level
  d) satellite level.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite EMC/RFC Analysis
SY-12	

PURPOSE OF DOCUMENT

To analyse in depth the proposed METOP design concept from Phase A and to follow up all evolutions of the design in Phase B concerning EMC and RFC critical areas.

Furthermore, all necessary analysis/trade-off's shall be performed to establish the basic EMC/RFC design and test requirements. These analyses shall form the baseline for deriving the satellite level EMC/RFC requirements.

CONTENTS

Satellite EMC/RFC analysis to cover at least the following EMC/RFC issues:

- grounding concept
- magnetic compatibility
- conducted compatibility
- radiated compatibility
- radio frequency compatibility
- EMC/RFC test/verification approach (unit to satellite level)

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite EMC/RFC Control Plan
SY-13	

PURPOSE OF DOCUMENT

To define the Electromagnetic Compatibility and Radio-Frequency Compatibility Control Program to be initiated by the Contractor on the METOP project. Specifically the plan shall describe the overall approach, planning, technical criteria and management controls to meet satellite compatibility requirements.

CONTENTS

The EMC/RFC control plan shall comprise at least the following subjects:

- EMC/RFC program management
- EMC/RFC documentation (to be generated by the Prime Contractor and subcontractors)
- EMC/RFC control activities
- EMC/RFC design criteria/techniques
- test and verification concept

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Satellite EMC/RFC and Power Quality Requirements Specification
SY-14		

PURPOSE OF DOCUMENT

To establish the overall satellite EMC/RFC requirements in order to ensure electromagnetic compatibility of the spacecraft and its associated GSE in all modes of operation (on-ground and in-orbit). Furthermore, the EMC/RFC requirements shall be broken down to sub-system/unit level as appropriate.

An EMC/RFC test/verification concept shall be defined to demonstrate the implementation/verification of the EMC/RFC requirements from satellite level down to unit level and for the GSE.

CONTENTS

The EMC/RFC requirement specification shall cover at least the following items:

- EMC design requirements
  (bonding, isolation, grounding, cabling, frequency selection etc.)
- magnetic requirements
- conducted emission/susceptibility requirements
- radiated emission/susceptibility requirements
- RF compatibility requirements
- GSE EMC requirements
- EMC test requirements (test specification)
- EMC verification requirements (test plan)
- power quality requirements

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Satellite Requirements on Ariane Launcher System
SY-15		

PURPOSE OF DOCUMENT

To define the METOP spacecraft requirements with regard to mission and trajectory to polar orbit, dynamic and thermal environment, accessibility, RF transparency and umbilical cables which shall serve as the Agency's input to the launch system/METOP interface control file

CONTENTS

To define the satellite requirements on the Ariane launcher system in terms of:

- mission characteristics and constraints
- spacecraft launch and flight configuration
- spacecraft mechanical properties and interfaces
- thermal interfaces
- operational interfaces and safety
- umbilical link electrical interfaces and grounding
- RF transparency
- environmental requirements during on-ground handling and storage and launch
  preparation and launch phase
- contamination requirements
- launch facilities interfaces

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Software Engineering Standards
SY-16	

PURPOSE OF DOCUMENT

To establish mandatory standards and recommended conventions to be applied for software production with dedicated sections for On-Board S/W, Check-Out S/W, Performance/Analysis/Simulation S/W, Pre-developed S/W, Single-Used S/W, and Vendor-Provided S/W. The standards and conventions shall include S/W life cycle, documentation, design and coding, verification and testing, review activities, configuration control and product assurance.

CONTENTS

A section on each of the standards/conventions (i.e. Life Cycle documentation, etc.) for each of the products (i.e. On-Board S/W, Check -Out S/W, etc.) listed in the "purpose" section above.

The Contractor shall use AD36 of Annex A as a reference to be revised and updated to METOP requirements.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Satellite Software Design, Development and Verification Plan
SY-17		

PURPOSE OF DOCUMENT

To establish for all on-board S/W, a plan for all the software activities to be performed during the entire software life cycle, starting with the specification of the S/W requirements and ending with the delivery of the fully tested S/W.
The tools required for the different S/W activities shall also be defined.

CONTENTS

To provide a list of all S/W documents to be delivered, together with a brief description of the purpose and contents of each document, including:

- S/W Requirements Documents (SRD) *
- S/W Architectural Design Document (ADD) *
- S/W Detailed Design Document (DDD)
- S/W Budgets (can be part of unit level Budgets Doc.) **
- S/W Test Plan **
- S/W Test Procedures **
- S/W Test Report
- S/W Integration Plan **
- S/W Integration Procedures **
- S/W Configuration Status List **
- S/W Users Manual
- H/W-S/W Integration Docs **
- source listing
- S/W Development Environment (SDE) definition, including selection of one high-level programming language. *
- specification of all S/W reviews and major S/W milestones.

* To be delivered during Phase B.
** Preliminary version only during Phase B.

Note: This Document is applicable to all on-board S/W under this statement of work including instruments and sub-systems.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Satellite to Ground Support Equipment Interface Specification
SY-18		

PURPOSE OF DOCUMENT

To define all interfaces, mechanical, electrical, thermal and RF between the METOP satellites and their associated Ground Support Equipment (GSE).

CONTENTS

Satellite to GSE interface specifications in terms of:

- general requirements
- electrical interfaces (including pyrotechnics)
- power distribution (e.g. solar array simulator)
- TT&C interface (e.g. ground segment simulator)
- RF/GSE interface
- payload/GSE I/F
- satellite thermal interface
- satellite/GSE mechanical interfaces (for lifting/transportation)
- satellite conputerised data base
- satellite simulator (optional) for training

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Satellite to Test Facility Interface Specification
SY-19		

PURPOSE OF DOCUMENT

To define all interfaces between the various METOP satellite, payload and platform models, structural thermal model (STM), engineering model (EM), protoflight model (PFM) and recurrent flight models (REC. FM) plus associated GSE and all assembly, integration and test (AIT) facilities.

CONTENTS

Satellite plus GSE to Test Facility Interface Specs. for selected test facilities for:

- satellite AIT
- mass properties
- static load and stiffness
- modal survey
- acoustic noise
- vibration
- EMC/RFC
- TB/TV

plus:
- general requirements and PA

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Platform/Payload Interface Spec.
SY-20	

PURPOSE OF DOCUMENT

To define payload/platform interfaces, including mechanical, electrical, thermal, software, environmental and GSE.

CONTENTS

Payload/platform interfaces specs in terms of:

- general requirements
- all electrical interfaces
- all mechanical interfaces
- all thermal interfaces
- all GSE interfaces
- all software interfaces
- environmental requirements
- operational requirements
- PA

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Mechanical/Thermal Design Requirements
SY-21	

PURPOSE OF DOCUMENT

To define a common set of mechanical and thermal design requirements and rules for use in mechanical and thermal design activities at satellite, payload and platform instrument/sub-system and equipment level.

CONTENTS

Mechanical and thermal design requirements in terms of:

- mechanical design requirements (including reference configuration and coordinate system)
- structure performance requirements (including safety factors and margins)
- structure analysis requirements (including static, dynamic, stress and thermal distortion, and structure interfaces)
- thermal design requirements and performance characteristics
- maintenance, verification and PA requirements.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Platform/Payload Interface Spec.
SY-20	

PURPOSE OF DOCUMENT

To define payload/platform interfaces, including mechanical, electrical, thermal, software, environmental and GSE.

CONTENTS

Payload/platform interfaces specs in terms of:

- general requirements
- all electrical interfaces
- all mechanical interfaces
- all thermal interfaces
- all GSE interfaces
- all software interfaces
- environmental requirements
- operational requirements
- PA

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Mechanical/Thermal Design Requirements
SY-21	

PURPOSE OF DOCUMENT

To define a common set of mechanical and thermal design requirements and rules for use in mechanical and thermal design activities at satellite, payload and platform instrument/sub-system and equipment level.

CONTENTS

Mechanical and thermal design requirements in terms of:

- mechanical design requirements (including reference configuration and coordinate system)
- structure performance requirements (including safety factors and margins)
- structure analysis requirements (including static, dynamic, stress and thermal distortion, and structure interfaces)
- thermal design requirements and performance characteristics
- maintenance, verification and PA requirements.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Electrical Design Requirements
SY-22	

PURPOSE OF DOCUMENT

To define a common set of electrical design requirements and guidelines for METOP to be applied at satellite, payload and platform, instrument/sub-system and equipment level.

CONTENTS

Satellite electrical design requirements in terms of:

- general design approach (covering design specs. and performance verification)
- basic electrical design requirements
- design guidelines for optical and RF equipments
- design rules for data management electrical systems
- power generation and distribution
- cable harness and connectors
- electrical systems structural and electrical integrity
- general requirements on verification and PA

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Cleanliness Design Requirements
SY-23	

PURPOSE OF DOCUMENT

To identify high risk and critical areas on the spacecraft and specify acceptable levels for contamination, both particulate and molecular, and to further identify critical stages in the development, integration and verification phases of the METOP project.

CONTENTS

Satellite cleanliness design requirements in terms of:

- parts, equipment and sensitive areas
- contamination critical phases
- typical contaminants and their sources
- environmental factors, including expected temperatures
- expected effects of contaminants on critical parts
- acceptable contamination levels
- general PA aspects and responsibilities

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Safety Design Requirements
SY-24	

PURPOSE OF DOCUMENT

To define the safety technical requirements for METOP and the associated ground support equipment (GSE) to protect personnel, equipment and property against hazards presented by the satellite, the associated GSE and related ground operations.

CONTENTS

Satellite safety design requirements in terms of:

- general safety requirements
- applicable national and transportation standards
- satellite and associated GSE design requirements, covering:
    - pressurized systems, including vessels, pipes and fittings
    - hazardous, toxic and flammable materials
    - pyrotechnics and igniters
    - cryogenics
    - high voltages

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Flight Operations Manual
SY-25	

PURPOSE OF DOCUMENT

To define, in full detail, the in-orbit operational characteristic of the satellite, its sub-systems and instruments..

CONTENTS

Outline of Document only in Phase B, covering:

- Nominal Cases
- LEOP
- Contingencies.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Sub-Systems Interface Specification
SY-26	

PURPOSE OF DOCUMENT

To define the interfaces between satellite sub-systems, related functional, electrical and operational aspects, as well as mechanical and thermal interfaces not covered by the environmental requirements specifications.

CONTENTS

Interface Specification in terms of:

- general requirements
- mechanical interfaces (including physical properties, local reference, mounting/accommodation, AIV interfaces)
- thermal interfaces (including surface treatment, thermal insulation, thermal conductances)
- electrical interfaces (including power supply, avionics, timings, housekeeping interface)
- functional interfaces between sub-systems.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite Frequency Plan
SY-27	

PURPOSE OF DOCUMENT

List all frequencies used by METOP equipment.

CONTENTS

Including all frequencies generated on-board for transmitters, local oscillators and clock-sources, used by RF receivers, both on equipment and instruments.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Command and Control Interface Specification
SY-28	

PURPOSE OF DOCUMENT

To specify all command and control interfaces.

CONTENTS

The Contractor shall use AD 32 of Annex A as a reference to be ervised and updated to a METOP Command and Control Interface Specification.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Platform Technical Description
PF-1	

PURPOSE OF DOCUMENT

To describe the platform design and its operational, functional and performance characteristics from platform level down to equipment level.

CONTENTS

Platform description in terms of:

- main characteristics
- operational modes
- functional modes
- performance summary
- block diagram down to sub-system/equipment level with description of each sub-system/equipment block
- main electrical interfaces

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Platform Design Specifications
PF-2	

PURPOSE OF DOCUMENT

To specify design at platform level in terms of performance, interface specifications and verification requirements.

CONTENTS

Platform design specifications in terms of:

- general function
- performance requirements
- electrical interfaces (RF, signals, power, telemetry)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- operational requirements (e.g. reliability and lifetime)
- EGSE/MGSE/STE requirements
- PA (including model philosophy)
- summary test sequence and detailed test matrices

Interfaces to the payload are covered in SY-20.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Platform Sub-system Specifications
PF-3	

PURPOSE OF DOCUMENT

To specify the platform design at sub-system level in terms of performance, interface specifications and verification requirements.

CONTENTS

Sub-system design specifications in terms of:

- general function
- performance requirements
- electrical interfaces (i.e. signals, power, telemetry)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- EMC/RFC design and test requirements
- EGSE/MGSE/STE requirements
- operational requirements (e.g. reliability and lifetime)
- PA (including model philosophy)
- summary test sequence and detailed test matrices

The platform sub-system shall include:

structure, thermal control, propulsion, AOCS, power supply, solar array, OBDH, OBC, communications.

Where platform specifications form part of the METOP satellite specification, they shall be delivered within the framework of SY-2.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Platform Equipment Specification
PF-4	

PURPOSE OF DOCUMENT

To specify the platform design at equipment level in terms of performance, detailed interface specifications and verification requirements.

CONTENTS

Equipment design specifications in terms of:

- general function
- performance requirements
- electrical interfaces (RF, signals, power, telemetry)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- EMC/RFC design and test requirements
- operational requirements (e.g. reliability and lifetime)
- EGSE/MGSE/STE requirements
- PA (including model philosophy)
- summary test sequence and detailed test matrices
- handling, transportation and storage requirements

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Platform Verification and Test Plan
PF-5	

PURPOSE OF DOCUMENT

To define the full qualification and acceptance test programmes from platform level down to equipment level.

To establish the on-ground verification planning and control from platform level to equipment level.

CONTENTS

Qualification and acceptance test programme definition in terms of:

- test philosophy
- test conditions
- hardware/software matrices
- qualification test programme (involving functional testing at ambient, qualification level vibration and TV test limits, TV profile and EMC/RFC)
- acceptane level programme (involving functional testing at ambient, acceptance level, vibration and TV test limits, TV profile and EMC/RFC)
- test plan and methods
- PA provisions

Verification planning, to include at least:

- verification approach
- verification planning
- verification control
- responsibilities
- verification summary matrix

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Platform Design and Development Plan
PF-6		

PURPOSE OF DOCUMENT

To define the overall platform design/development philosophy from engineering design through integration and verification while taking into account schedule and programme constraints.

CONTENTS

Design/development plan definition in terms of:

- platform requirements and constraints
- hardware and software breakdown, where applicable
- platform verification concept
- development plan (covering manufacturing, integration and test plans and model philosophy)
- general design and engineering aspects (including performance, mechanical/thermal, electrical design, EMC/RFC aspects, software development and validation, EGSE/MGSE)
- summary schedule and milestones
- compliance to system/satellite level requirements

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Payload Support Sub-system Technical Description
SS-1		

PURPOSE OF DOCUMENT

To describe the payload support sub-system design and its operational and functional characteristics from sub-system level down to equipment level.

CONTENTS

Sub-system description in terms of:

- main characteristics
- operational modes
- functional modes
- block diagram down to equipment level with description of each equipment block
- main electrical interfaces

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Payload Support Sub-system Design Specifications
SS-2		

PURPOSE OF DOCUMENT

To specify design at sub-system level in terms of performance, interface specifications and verification requirements.

CONTENTS

Sub-system design specifications in terms of:

- general function
- performance requirements
- electrical interfaces (i.e. signals, power, telemetry)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- EMC/RFC design and test requirements
- EGSE/MGSE/STE requirements
- operational requirements (e.g. reliability and lifetime)
- PA (including model philosophy)
- summary test sequence and detailed test matrices

The payload support sub-system shall include:

- payload support structure
- payload thermal control
- payload power supply and distribution
- payload harness
- payload OBDH

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Payload Sub-system Suppor Equipment Specifications
SS-3		

PURPOSE OF DOCUMENT

To specify the design at equipment level in terms of performance, detailed interface specifications and verification requirements.

CONTENTS

Equipment design specifications in terms of:

- general function
- performance requirements
- electrical interfaces (i.e. signals, power, telemetry)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- EMC/RFC design and test requirements
- operational requirements (e.g. reliability and lifetime)
- EGSE/MGSE/STE requirements
- PA (including model philosophy)
- summary test sequence and detailed test matrices
- handling, transportation and storage requirements

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Payload Support Sub-system Verification and Test Plan
SS-4		

PURPOSE OF DOCUMENT

To define the full qualification and acceptance test programmes from sub-system level down to equipment level.

To establish the on-ground verification planning and control from sub-system level to equipment level.

CONTENTS

Qualification and acceptance test programme definition in terms of:

- test philosophy
- test conditions
- hardware/software matrices
- qualification test programme (involving functional testing at ambient, qualification level vibration and TV test limits and profile specifications and EMC/RFC)
- acceptance test programme (involving functional test at ambient, acceptance level vibration and TV test limits and profile and EMC/RFC)
- test plan and methods
- PA provisions

Verification planning, to include at least:

- verification approach
- verification planning
- verification control
- responsibilities
- verification summary matrix

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Payload Support Sub-system Verification and Test Plan
SS-4		

PURPOSE OF DOCUMENT

To define the full qualification and acceptance test programmes from sub-system level down to equipment level.

To establish the on-ground verification planning and control from sub-system level to equipment level.

CONTENTS

Qualification and acceptance test programme definition in terms of:

- test philosophy
- test conditions
- hardware/software matrices
- qualification test programme (involving functional testing at ambient, qualification level vibration and TV test limits and profile specifications and EMC/RFC)
- acceptance test programme (involving functional test at ambient, acceptance level vibration and TV test limits and profile and EMC/RFC)
- test plan and methods
- PA provisions

Verification planning, to include at least:

- verification approach
- verification planning
- verification control
- responsibilities
- verification summary matrix

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Payload Support Sub-system Design and Development Plan
SS-5		

PURPOSE OF DOCUMENT

To define the overall sub-system design/development philosophy from engineering design through integration and verification while taking into account schedule and programme constraints.

CONTENTS

Design/development plan definition in terms of:

- sub-system requirements and constraints
- hardware and software breakdown
- sub-system verification concept
- development plan (covering manufacturing, integration and test phases and model philosophy)
- general design and engineering aspects (including performance, mechanical/thermal, electrical design, EMC/RFC aspects, software development and validation, EGSE/MGSE)
- summary schedule and milestones
- compliance to system/satellite level requirements

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Advanced Scatterometer (ASCAT) Instrument Technical Description
AS-1	

PURPOSE OF DOCUMENT

To describe the ASCAT design and its operational, functional and performance characteristics from ASCAT level down to equipment level.

CONTENTS

ASCAT description in terms of:

- main characterisation
- operational modes
- functional modes
- performance summary
- block diagram down to equipment level with description of each equipment block
- main electrical interfaces

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Advanced Scatterometer (ASCAT) Instrument Design and Performance Specifications
AS-2		

PURPOSE OF DOCUMENT

To specify design at ASCAT level in terms of measurement performance, interface specifications and verification requirements.

CONTENTS

ASCAT design specifications in terms of:

- general function, operational mode
- performance requirements
- electrical interfaces (RF, signal, power, telemetry, data handling)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- EMC/RFC design and test requirements
- EGSE/MGSE/STE requirements
- operational requirements (e.g. reliability and lifetime)
- PA (including model philosophy)
- summary test sequence and detailed test matrices

The Contractor shall provide, as minimum, performance specifications with respect to:

- Engineering parameters at instrument level e.g.
  - spatial, spectral, sampling resolution
  - radiometric, resolution, accuracy, stability
  - aliasing, ambuigities
  - coverage
  - calibration, characterisation performance.

- Sub-system key parameters, e.g.
  - peak power
  - timelining
  - receiver noise figure
  - harness losses
  - frequency, bandwidth, VSWR, etc.
  - etc.

The Contractor shall rely heavily on previous studies.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Advanced Scatterometer (ASCAT) Instrument Sub-System Specifications
AS-3		

PURPOSE OF DOCUMENT

To specify the ASCAT design at sub-system/equipment level in terms of performance, detailed interface specifications and verification requirements.

CONTENTS

ASCAT design specifications in terms of:

- general function
- performance requirements
- electrical interfaces (RF, signal, power, telemetry)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- EMC/RFC design and test requirements
- EGSE/MGSE/STE requirements
- operational requirements (e.g. reliability and lifetime)
- PA (including model philosophy)
- summary test sequence and detailed test matrices
- handling, transportation and storage requirements

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Advanced Scatterometer (ASCAT) Instrument Verification, Test, Calibration and Characterisation Plan
AS-4		

PURPOSE OF DOCUMENT

To define the full instrument calibration, characterisation and test programme from instrument level down to sub-system/equipment level.

To establish the instrument on-ground verification planning and control from instrument level down to sub-system/equipment level.

CONTENTS

Calibration, characterisation and test programme definition in terms of:

- calibration/characterisation and test philosophy
- error budget definition and combination
- calibration, characterisation, test planning and methods
- qualification test programme (including environmental tests, test limits,
  test sequence and profiles)
- acceptance test programme (including environmental tests, test limits, test sequence and profiles)
- calibration curves definition
- PA provisions.

Verification planning, to include at least:

- verification approach
- verification planning
- verification control
- responsibilities
- verification summary matrix

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Advanced Scatterometer (ASCAT) Instrument Design and Development Plan
AS-5		

PURPOSE OF DOCUMENT

To define the overall ASCAT design/development philosophy from engineering design through integration and verification and calibration while taking into account schedule and programme constraints.

CONTENTS

Design/development plan definition in terms of:

- ASCAT requirements and constraints
- hardware and software breakdown
- ASCAT verification concept
- development plan (covering manufacturing, integration, test and calibration plans and model philosophy)
- general design and engineering aspects (including performance, mechanical/ thermal, electrical/RF design, EMC/RFC aspects, software development and validation, EGSE/MGSE)
- summary schedule and milestones
- compliance to system/satellite requirements.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Instrument Interface Control Document (ICD)
AS-6	

PURPOSE OF DOCUMENT

To define all the requirements on the instrument specific interfaces, mechanical, thermal, electrical, environmental and operational, between the ASCAT instrument and the METOP satellite.

CONTENTS

Interface Specifications in terms of:

- general requirements
- mechanical interfaces (including physical properties, local reference, design loads, structural interfaces, dynamic interfaces, alignment/pointing, field of view, mounting, AIV interfaces)
- thermal interfaces (including thermal environmental conditions, thermal limits and dissipations, heat capacities, surface treatment and thermal insulation, thermal conductances)
- electrical interfaces (including power supply interfaces, command and control I/F, timings, datation)
- science data interface, housekeeping TM
- deliverable mathematical models (e.g. reduced thermal mathematical model and reduced finite element model).

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Multifrequency Image Microwave Radiometer (MIMR) Instrument Technical Description
MI-1		

PURPOSE OF DOCUMENT

To describe the MIMR design and its operational, functional and performance characteristics from MIMR level down to equipment level.

CONTENTS

MIMR description in terms of:

- main characterisation
- operational modes
- functional modes
- performance summary
- block diagram down to equipment level with description of each equipment block
- main electrical interfaces
- budgets summary for mass, power, volume, performance, etc.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Multifrequency Image Microwave Radiometer (MIMR) Instrument Design and Performance Specifications
MI-2		

PURPOSE OF DOCUMENT

To specify design at MIMR level in terms of measurement performance, interface specifications and verification requirements.

CONTENTS

MIMR design specifications in terms of:

- general function, operational
- performance requirements
- electrical interfaces (RF, signal, power, telemetry, data handling)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- EMC/RFC design and test requirements
- EGSE/MGSE/STE requirements
- operational requirements (e.g. reliability and lifetime)
- QA (including model philosophy)
- summary test sequence and detailed test matrices

The Contractor shall provide, as a minimum, performance specifications with respect to:

- Engineering parameters at instrument level
  - radiometric sensitivity, accuracy, stability
  - localisation accuracy
  - spatial resolution
  - pointing accuracy, stability
  - residual momentum, static and dynamic unbalance
  - calibration/characterisation performances.

- Sub-system key parameters:
  - receiver noise temperature per channel
  - receiver linearity
  - antenna beam efficiency, side lobe level, etc.
  - scan and balance mechanism performances
  - harness losses
  - etc.

The Contractor shall rely heavily on previous studies.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Multifrequency Image Microwave Radiometer (MIMR) Instrument Sub-System Specifications
MI-3		

PURPOSE OF DOCUMENT

To specify the MIMR design at sub-system/equipment level in terms of performance, detailed interface specifications and verification requirements.

CONTENTS

ASCAT design specifications in terms of:

- general function
- performance requirements
- electrical interfaces (RF, signal, power, telemetry)
- mechanical interfaces
- thermal interfaces
- mechanical and thermal environmental requirements
- EMC/RFC design and test requirements
- EGSE/MGSE/STE requirements
- operational requirements (e.g. reliability and lifetime)
- PA (including model philosophy)
- summary test sequence and detailed test matrices
- handling, transportation and storage requirements

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Multifrequency Image Microwave Radiometer (MIMR) Instrument Validation, Test, Calibration and Characterisation Plan
MI-4		

PURPOSE OF DOCUMENT

To define the full instrument calibration, characterisation and test programme from instrument level down to sub-system/equipment level.

To establish the on-ground verification planning and control from instrument level down to sub-system/equipment level.

CONTENTS

Calibration, characterisation and test programme definition in terms of:

- calibration/characterisation and test philosophy
- error budget definition and combination
- calibration, characterisation, test planning and methods
- qualification test programme (including environmental tests, test limits,
  test sequence and profiles)
- acceptance test programme (including environmental tests, test limits, test sequence and profiles)
- calibration curves definition
- PA provisions.

Verification planning, to include at least:

- verification approach
- verification planning
- verification control
- responsibilities
- verification summary matrix

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Multifrequency Image Microwave Radiometer (MIMR) Instrument, Design and Development Plan
MI-5		

PURPOSE OF DOCUMENT

To define the overall MIMR design/development philosophy from engineering design through integration and verification and calibration while taking into account schedule and programme constraints.

CONTENTS

Design/development plan definition in terms of:

- MIMR requirements and constraints
- hardware and software breakdown
- MIMR verification concept
- development plan (covering manufacturing, integration, test and calibration plans and model philosophy)
- general design and engineering aspects (including performance, mechanical/ thermal, electrical/RF design, EMC/RFC aspects, software development and validation, EGSE/MGSE)
- summary schedule and milestones
- compliance to system/satellite requirements.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Instrument Interface Control Document (ICD)
MI-6	

PURPOSE OF DOCUMENT

To define all the requirements on the instrument specific interfaces, mechanical, thermal, electrical, environmental and operational, between the MIMR instrument and the METOP satellite.

CONTENTS

Interface Specifications in terms of:

- general requirements
- mechanical interfaces (including physical properties, local reference, design loads, structural interfaces, dynamic interfaces, alignment/pointing, field of view, mounting, AIV interfaces)
- thermal interfaces (including thermal environmental conditions, thermal limits and dissipations, heat capacities, surface treatment and thermal insulation, thermal conductances)
- electrical interfaces (including power supply interfaces, command and control I/F, timings, datation)
- science data interface, housekeeping TM
- deliverable mathematical models
  (e.g. reduced thermal mathematical model and reduced finite element model).

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE General Instrument Interface Control Document (GICD)
CF-1	

PURPOSE OF DOCUMENT

To define all the general requirements on the relevant interfaces, mechanical, thermal, electrical, environmental and operational, between customer furnished instruments (CFI) and the METOP satellite.

CONTENTS

Interface Specifications in terms of:

- general requirements
- mechanical interfaces (including physical properties, local reference, design loads, structural interfaces, dynamic interfaces, alignment/pointing, field of view, mounting, AIV interfaces)
- thermal interfaces (including thermal environmental conditions, thermal limits and dissipations, heat capacities, surface treatment and thermal insulation, thermal conductances)
- electrical interfaces (including power supply interfaces, command and control I/F, timings, datation)
- science data interface, housekeeping TM
- environmental interfaces (including EMC/RFC)
- instrument design and verification requirements
- instrument operations
- GSE
- QA aspects (including cleanliness requirements and contamination control)
- programme and schedule

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Instrument Interface Control Document (ICD)
CF-2	

PURPOSE OF DOCUMENT

To define all the requirements on the instrument specific interfaces, mechanical, thermal, electrical, environmental and operational, between the CFI instrument and the METOP satellite.

CONTENTS

Interface Specifications in terms of:

- general requirements
- mechanical interfaces (including physical properties, local reference, design loads, structural interfaces, dynamic interfaces, alignment/pointing, field of view, mounting, AIV interfaces)
- thermal interfaces (including thermal environmental conditions, thermal limits and dissipations, heat capacities, surface treatment and thermal insulation, thermal conductances)
- electrical interfaces (including power supply interfaces, command and control I/F, timings, datation)
- science data interface, housekeeping TM
- environmental interfaces (including EMC/RFC)
- instrument design and verification requirements
- instrument operations
- GSE
- QA aspects (including cleanliness requirements and contamination control)
- programme and schedule

One ICD is required for each of the instruments specified in Annex A, para A 3.4.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Satellite System Verification Plan
AV-1	

PURPOSE OF DOCUMENT

To establish the METOP satellite system on-ground and in-orbit verification planning and control from satellite level down to instrument/sub-system level.

CONTENTS

Verification planning, to include at least:

- verification approach
- verification planning
- verification control
- responsibilities
- verification summary matrix

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Assembly, Integration and Test Plan
AV-2	

PURPOSE OF DOCUMENT

To define and control the METOP satellite system assembly, integration and test plan from instrument/sub-system level up to satellite level.

CONTENTS

AIT planning, to include:

- AIT approach
- AIT planning
- AIT control
- AIT responsibilities

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE GSE Requirements Spec.
AV-3	

PURPOSE OF DOCUMENT

To establish the general requirements for the Ground-Support Equipment (GSE) comprising the Electrical Ground Support Equipment (EGSE) and the Mechanical Ground Support Equipment (MGSE) for instrument, sub-system, payload, platform and satellite level.

CONTENTS

General GSE requirements, including at least:

- GSE definition
- operational requirements
- interface requirements
- software requirements
- hardware design and construction requirements
- EMC requirements
- environmental requirements
- Product Assurance
- preparation and delivery

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Facilities and Transportation Plan
AV-4	

PURPOSE OF DOCUMENT

To define and plan the provision of suitable test facilities and means of transportation for METOP satellite system.

CONTENTS

Facilities and transportation planning, to include:

- list of proposed test activities
- proposed test facility
- schedule for test facility availability
- means of transportation, including:
  - items to be transported
  - requirements on transportation
  - transport responsibility
  - transportation planning.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Hardware and Software Matrix
AV-5	

PURPOSE OF DOCUMENT

To list the deliverable items of hardware and software of the METOP satellite system including spare and GSE.

CONTENTS

Hardware and software matrix, covering at least:

- satellite hardware and software
- GSE hardware and software

- simulation software
- CFE list

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE EGSE Design Specifications
AV-6	

PURPOSE OF DOCUMENT

To define the design requirements for METOP satellite EGSE, from system level down to instrument level.

CONTENTS

EGSE Design Specifications, to include, at least:

- satellite EGSE definition
- performance requirements
- operational requirements
- interface requirements
- software requirements
- hardware requirements
- PA aspects

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Hardware and Software Matrix
AV-5	

PURPOSE OF DOCUMENT

To list the deliverable items of hardware and software of the METOP satellite system including spare and GSE.

CONTENTS

Hardware and software matrix, covering at least:

- satellite hardware and software
- GSE hardware and software
- simulation software
- CFE list

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Hardware and Software Matrix
AV-5	

PURPOSE OF DOCUMENT

To list the deliverable items of hardware and software of the METOP satellite system including spare and GSE.

CONTENTS

Hardware and software matrix, covering at least:

- satellite hardware and software
- GSE hardware and software
- simulation software
- CFE list

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE EGSE Design Specifications
AV-6	

PURPOSE OF DOCUMENT

To define the design requirements for METOP satellite EGSE, from system level down to instrument level.

CONTENTS

EGSE Design Specifications, to include, at least:

- satellite EGSE definition
- performance requirements
- operational requirements
- interface requirements
- software requirements
- hardware requirements
- PA aspects

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE MGSE Design Specifications
AV-7	

PURPOSE OF DOCUMENT

To establish the design, performance and testing requirements of the METOP satellite mechanical ground support equipment, from system level down to instrument level.

CONTENTS

MGSE Design Specifications to include:

- MGSE definition and identification
- equipment description
- interface requirements
- mechanical requirements
- electrical/EMC requirements (for electric motors, etc.)
- design and constructional requirements
- environmental requirements

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE EGSE Development Plan
AV-8	

PURPOSE OF DOCUMENT

To define the overall EGSE (instrument sub-system, payload, platform and satellite level) development philosophy from engineering design through integration and verification taking into account schedule and programme constraints.

CONTENTS

Development plan definition in terms of:

- EGSE requirements and constraints
- hardware and software breakdown
  (including satellite simulators and satellite computerised data base)
- EGSE verification concept
- development plan (covering manufacturing, integration and test phases and identification of optimum number of EGSE sets)
- general design and engineering aspects (including performance, mechanical/ thermal, electrical design, software development and validation)
- summary schedule and milestones
- compliance to requirements and design specs.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE MGSE Development Plan
AV-9	

PURPOSE OF DOCUMENT

To define the overall MGSE (instument, sub-system, payload, platform and satellite level) development philosophy from engineering design through integration and verification while taking into account schedule and programme constraints.

CONTENTS

Development plan definition in terms of:

- MGSE requirements and constraints
- hardware breakdown
- MGSE verification concept
- development plan (covering manufacturing, integration and test phases and identification of optimum number of MGSE sets)
- general design and engineering aspects
- summary schedule and milestones
- compliance to requirements and design specs.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE	Launch and Commissioning Phase Support Activities Plan
AV-10		

PURPOSE OF DOCUMENT

To define all industrial launch and commissioning support activities for METOP and provide planning.

CONTENTS

Launch support, also covering LEOP and first payoad switch-on activities and commissioning phase activities.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE AIV/GSE Technical Notes
AV-11	

PURPOSE OF DOCUMENT

To provide all supporting AIV/GSE technical notes and analyses.

CONTENTS

AIV/GSE technical notes and analyses.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Product Assurance Plan
P-1	

PURPOSE OF DOCUMENT

To establish the provisions for the METOP Product Assurance Programme covering the planning, organisation and controls to ensure an effective and economic programme for the design, manufacture and delivery of all products in compliance with the METOP-1 ESA Product Assurance Requirements.

CONTENTS

The plan shall describe the following items:

- Product Assurance Organization
- Tasks and Schedule: the PA tasks to be undertaken together with the relationship of these tasks to the overall programme milestones.
- Deliverables.
- Documentation: definition or reference to the product assurance design rules, standards, practices, methods, procedures.
- Reporting: This section shall define the system used to report activity status, progress and problem areas.
- Statement of applicability and compliance to each para. of the METOP-1 ESA Product Assurance Requirements (including tailored PSS-01-Series requirements).
- PA requirements imposed on sub-contractors.

EEE Components Control, Fracture Control and Configuration Management can be covered by separated plans outside the PA plan.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Reliability Prediction Report
P-2	

PURPOSE OF DOCUMENT

To provide an overall METOP-1 Satellite system Reliability estimate based on an apportionment of reliability estimates for all satellite sub-systems and instruments.

CONTENTS

Satellite sub-system/instrument reliability figures leading to an overall satellite system reliability estimate with compliance to overall satellite system requirements.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE FMECA Report
P-3	

PURPOSE OF DOCUMENT

To analyse METOP-1 Satellite System and external interfaces to identify functional failure modes, causes, criticalities and effects, for the purpose of achieving a design compliant with the requirements.

CONTENTS

The FMECA report shall contain the results of the FMECA analyses and data sources and techniques. The FMECA shall address hardware as well as software functional failure modes, effects and criticalities.

The FMECA report shall include all information necessary for understanding and review of the analysis :

- identification of configuration being analysed
- identification of applicable functional description and reliability block diagrams
- identification of operational phase and operational mode under consideration
- identification of level of analysis, the assumed failure mode and the effect on other equipment/subsystems

The analysis results shall be used in order to :

- support hazard analysis
- identify single-point failures
- identify critical items
- ensure that adequate telemetry and command capabilities are available to detect and control failures
- identify design incompatibilities and inadequacies
- verify that all redundant elements can be tested at integrated system
- identify monitoring capabilities in orbit (and test)
- identify back-up operation modes and procedures
- to develop software requirements and to support S/W analyses
- generate contingency analyses
- Identify operational procedures
- identify special test and quality inspection points

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Hazard Analysis Report
P-4	

PURPOSE OF DOCUMENT

To identify hazardous conditions associated with METOP-1 design and operations, related accident scenarios, hazard reduction measures and their verification.

CONTENTS

The hazard analysis report shall cover :

- Ground operations : integration, test, transportation, handling and pre-launch operations.
- Space operations : space environment including meteorite/debris, space debris creation.

The HA results shall be documented using hazard analysis report sheets providing at least the following information :

- identification of affected item (sub-system, equipment, etc.)
- operational phase
- hazard
- description of undesirable event and consequences
- consequence category
- possible causes
- applicable safety requirements
- description of hazard reduction provisions
- recommendations for further investigation design changes, etc.
- verification methods
- rationale for retention
- closure / approval status

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE EEE Components Control Plan
P-5	

PURPOSE OF DOCUMENT

To define the proposed approach, methods, procedures organisation and schedule for METOP-1 component selection, procurement and control.

CONTENTS

The EEE component control plan shall include, but not be limited to, a detailed description of the following items :

- organisational structure, responsibilities and management approach
- major tasks and methods of implementation
- standardisation and control of component selection
- component evaluation and testing approach
- component testing level and lot acceptance
- component quality assurance activities
- requirements on and system for the control of subcontractors, procurement agents and manufacturers
- radiation control programme
- procurement system, including rationale for selection
- programme planning with schedule of tasks linked to spacecraft programme milestones
- reporting and deliverables
- compliance matrix

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Critical Items List
P-6.1	

PURPOSE OF DOCUMENT

To identify and track the status of all METOP-1 project critical items including single point failures, fracture critical and limited life items.

CONTENTS

The critical item list shall provide for each critical item the following information :

- Affected item identification, nomenclature, function
- Criticality description and related operational phase/mode
- Reference of the impacted requirement
- Effects at next higher levels
- Possible causes
- Cross reference to FMECA or other sources (establishing the criticality)
- Criticality ranking
- Proposed actions
- Agreed actions :
  - a) requirements waived
  - b) design change
  - c) special tests
  - d) inspection procedures
  - e) operational procedures
  - f) in-flight detection method
- Rationale for retention
- Closure / approval status

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE METOP Long-Lead Items List
P-6.2	

PURPOSE OF DOCUMENT

To define the required long-lead procurement items, for which advanced procurement is required (Phase B).

CONTENTS

Subsets of Declared Components Lists and Declared Mechanical Lists together with procurement information.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Declared Components List
P-6.3	

PURPOSE OF DOCUMENT

To establish a consolidated list of all EEE parts used in the METOP-1 design.

CONTENTS

The DCL shall contain all components types needed for the current design.

The information in the DCL shall be presented in the format given in Annex C to PSS-01-60.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Declared Materials List
P-6.4	

PURPOSE OF DOCUMENT

To establish a consolidated list of all materials used in the METOP-1 design.

CONTENTS

The DML shall include the following information :

- material type (commercial identification)
- chemical nature and type of product
- manufacturer(s); procurement specifications or standards
- summary of processing parameters
- use and location
- environmental code
- size code
- approval status (with reference to the approval authority and to test data)
- identification of limited-life materials

In case of re-use of 'fully qualified' subsystems, boxes or items, the corresponding materials should not appear in the system DML. The term 'fully qualified' means that the status of the element is traceable to a valid and complete qualification report containing a DML officially approved by the relevant ESA authority. This list is to be attached to the system DML for reference.

The information in the DML shall be presented in the format given in PSS-01-700.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Declared Process List
P-6.5	

PURPOSE OF DOCUMENT

To establish a consolidated list of all processes used in the METOP-1 design.

CONTENTS

The DPL shall include the following information :

- process identification
- related specification
- process description
- use and location
- manufacturer's name
- associated DML items
- criticality of the process
- approval status (with reference to the approval authority and to test data)

In case of re-use of 'fully qualified' subsystems, boxes or items, the corresponding processes should not appear in the DPL. The term 'fully qualified' means that the status of the element is traceable to a valid and complete qualification report containing a DPL officially approved by the relevant ESA authority. This list is to be attached to the system DPL for reference.

The information in the DPL shall be presented in the format given in PSS-01-700.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Preferred Parts List
P-6.6	

PURPOSE OF DOCUMENT

Control and minimise the variety of electronic components to be used in the METOP-1 project.

CONTENTS

The list shall contain an adequate range of components so to be capable of satisfying a wide range of METOP-1 design applications. The components shall be drawn from existing qualified and preferred parts lists, current programmes and new technologies where sufficient qualification data is available. The ESA preferred parts list ESA-PSS-01-603 shall be used as the primary basis for components selection.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Declared Mechanical-Parts List
P-6.7	

PURPOSE OF DOCUMENT

To establish a consolidated list of all mechanical-parts used in the METOP-1 design.

CONTENTS

The DMPL shall include the following information :

- commercial identification
- type of parts
- manufacturer(s); procurement specifications or standards
- summary of functions and characteristics
- use and location
- environmental code
- criticality and hazards
- approval status (with reference to the approval authority and to test data)

In case of re-use of 'fully qualified' subsystems, boxes or items, the corresponding mechanical-parts should not appear in the system DMPL. The term 'fully qualified' means that the status of the element is traceable to a valid and complete qualification report containing a DMPL officially approved by the relevant ESA authority. This list is to be attached to the system DMPL for reference.

The information in the DMPL shall be presented in the format given in PSS-01-700.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Configuration Management Plan
P-7	

PURPOSE OF DOCUMENT

To define the planning, organisation and procedures used to manage the configuration of METOP-1, including external and internal interfaces.

CONTENTS

The Configuration Management Plan shall :

- Include a milestone chart which depicts the CM activities and their relationship to the major overall project milestones.
- Describe the CM organisation. Identify the interrelationships, among the contractor's software and hardware CM organisations.
- Describe the organisation, authority and responsibility of the Configuration Control Board (CCB).
- Describe the methods for documents, physical items and software identification.
- Identify requirements for the standardisation, preparation, submission and subsequent release of configuration documents and controlled documents.
- Describe procedures for identifying both formal and internal (contractor) configuration baselines. All documents required to establish each baseline shall be listed as well as the procedure to be utilised for the control of such documents.
- Plan the selection of configuration items.
- Define procedures for processing of changes and waivers.
- Outline the recording, storing, handling, verifying, validating and presenting of configuration status information.
- Identify standard procedures for planning and conducting lower levels technical and qualification reviews.
- Describe interface management documents and procedures.
- CM requirements imposed on subcontractors and vendors.
- List of Configuration Items (Annex)

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Contamination Control Plan
P-8	

PURPOSE OF DOCUMENT

To define the methods, procedures and responsibilities in achieving and maintaining the cleanliness levels specified in the METOP-1 Satellite Cleanliness Design Requirements (SY-23).

CONTENTS

Contamination Control Plan shall cover at least :

- Contamination allowance for performance degradation and rationale for its selection.
- Cleanliness control management : tasks and responsibilities, schedule wrt project milestone, reporting, facilities audits, etc.
- Contamination analyses and contamination budget definition.
- Contamination control requirements during fabrication, integration test, launch.
- Measurements methods and cleanliness monitoring and verification activities.
- Procedures for removal of contamination.
- Protection methods and provisions.
- Contamination controls to be exercised during testing.
- Contamination controls for packaging, transportation and storage.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Audit Plan
P-9	

PURPOSE OF DOCUMENT

Provide information about planned audits of METOP-1 procurement sources.

CONTENTS

List the audits planned by the contractor. The list shall identify subcontractors and suppliers to be audited, audit baseline, current status and schedule, periodicity.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE PA Audit Report
P-9.1	

PURPOSE OF DOCUMENT

Provide information about results and actions of a PA Audit.

CONTENTS

The PA audit report shall contain :

- composition of the audit team
- audit baseline
- audit activity summary
- company profile and activities
- identified areas of non-compliance
- corrective actions and due dates
- overall conclusions

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Controlled Documents List
P-10	

PURPOSE OF DOCUMENT

To provide information about the status of METOP-1 documents.

CONTENTS

The documents list shall present the current status of all documents prepared under this contract and sorted by types.

The list shall provide the information for :

- identification
- title
- issue / revision / date
- DRD No.
- issuing company and distribution
- approval category
- contractual delivery dates

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE PA Progress Report
P-11	

PURPOSE OF DOCUMENT

To provide a report on all PA aspects of the METOP-1 programme to be provided at each programme milestone, review, progress meeting as part of the overall METOP-1 System Progress Report.

CONTENTS

The report shall as a minimum contain the following information

- Accomplishments.
- Work in Progress.
- Work Overdue.
- Status of Problems.
- Status of EEE parts procurement activities.
- Future Activities.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Review Data Package
P-12	

PURPOSE OF DOCUMENT

The provision of Data Packages for the Preliminary, and System Requirements METOP programme reviews.

CONTENTS

The Review Data Package shall consist of the A, R and I documentation as defined in the DRL for the review.

In addition, a dedicated review data package will be required. The contents of this package as well as the scope, objectives and organisation of the review itself will be defined in a review procedure to be issued by the Agency at the Kick-Off meeting and 2 months before the SRR.

DOCUMENT REQUIREMENT DESCRIPTION

DRL NO.	TITLE Fracture Control Plan
P-13	

PURPOSE OF DOCUMENT

To define the planning, organisation and procedures to manage the METOP-1 Fracture Control Programme.

CONTENTS

Fracture control is a set of requirements and procedures involving the application of analysis and design methodology manufacturing, inspection and test techniques and operating procedures to prevent structural failure due to the initiation of and/or propagation of flaws or crack-like defects during fabrication, testing and service life.

The fracture control plan shall show how the contractor will perform the fracture control tasks and verify the satisfactory completion. Each fracture control activity shall be identified and defined, the method of implementation summarised, and the implementation schedule specified against project milestones. All requirements and procedures shall be identified.

STATEMENT OF WORK AND TECHNICAL REQUIREMENTS

ANNEX G

LIST OF ACRONYMS

Prepared by: METOP Team

Approved by: P.G. Edwards 30/4/94

METOP Project Manager
Earth Observation Projects Department

AATSR	Advanced Along Track Scanning Radiometer
ADD	Architectural Design Document
AIT	Assembly, Integration & Test
AIV	Assembly, Integration and Verification
AMSU	Advanced Microwave Sounding Unit
AOCS	Attitude and Orbit Control System
AOS	Acquisition of Signal
ASCAT	Advanced Scatterometer
ASI	Italian Space Agency
ASIC	Application Specification Integration Circuit
AVHRR	Advanced Very High Resolution Radiometer
BAe	British Aerospace
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
CADU	Channel Access Data Unit
CCB	Configuration Control Board
CCS	Command & Control System
CCSDR	Consultative Committee Satellite Data Standards
CDR	Critical Design Review
CETeF	Coordinated European Test Facilities
CFE	Customer Furnished Equipment
CFI	Customer Furnished Instrument
CFRP	Carbon Fibre Reinforced Plastic
CNES	Centre National D'Etudes Spatiales (French Space Agency)
COTS	Commercial Off The Shelf software
CPS	Complementary Polar Satellite
CPU	Central Processor Unit
CRB	Change Review Board
CVCDU	Coded Virtual Channel Data Unit
DBMS	Data Base Management System
DCI	Document de Contrôle de Interface (Ariane)
DCS	Data Collection System
DDD	Detailed Design Document
DMS	Data Management System
DMSP	Defense Meteorological Satellite Programme
DOD	Department of Defence
DPA	Destructive Physical Analysis
DRD	Documentation Requirement Description
DRL	Documentation Requirements List
DRS	Data Relay Satellite
DSL	Depointing Signal Line
DSPG	Distributed Single Power Ground
EEE	Electronic, Electrical and Electromagnetic parts
EEPROM	Electrically Erasable Programmable Read Only Memory
EGSE	Electrical Ground Support Equipment
EIRP	Effective Isotropic Radiated Power
EM	Engineering Model
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EOPP	Earth Observation Preparatory Programme
EPS	Electrical Power Sub-System
EPS	EUMETSAT Polar System
FAR	Flight Acceptance Test
FEC	Forward Error Correction
FM	Flight Model
FMECA	Failure Modes, Effects and Criticality Analysis
FMU	Formatting and Multiplexer Unit
FOM	Flight Operations Manual
FOV	Field of View
FPM	Fine Pointing Mode
GCOS	Global Climate Observing System

GICD	General Interface Control Document
GOME	Global Ozone Monitoring Experiment
GPS	Global Positioning System
GSE	Ground Support Equipment
GS	Ground Segment
G/T	Gain over Temperature
HIRS	High Resolution Infrared Sounder
HRPT	High Rate Picture Transmission
HV	High Voltage
IASI	Infrared Advanced Sounding Interferometer
ICD	Interface Control Document
ICU	Intelligent Control Unit
IGBP	International Geosphere/Biosphere Programme
ITT	Invitation to Tender
KLM	Series of Meteorological Satellites (NOAA)
K/O	Kickoff
LEOP	Launch and Early Orbit Phase
LHCP	Left Hand Circulator Polarisation
LLI	Long Lead Items
LRPT	Low Rate Picture Transmission
MCP	Meteorological Communication Package
MDP	Maximum Design Pressure
MGSE	Mechanical Ground Support Equipment
MHS	Microwave Humidity Sounder
MIMR	Multi-Frequency Imaging Microwave Radiometer
MLI	Multi-Layer Insulation
MLST	Mean Local Solar Time
MMPP	Materials, Mechanical Parts, Processes
MRB	Material Review Board
MTL	Master Time Line
NIU	NOAA Interface Unit
NOAA	National Oceanic and Atmospheric Adminstration
OBC	On-Board Computer
OBDH	On-board Data Handling
OMI	Ozone Monitoring Instrument
PA	Product Assurance
PDHS	Payload Data Handling System
PDR	Preliminary Design Review
PFCI	Potential Fracture Critical Item
PMP	Project Management Plan
POES	Polar Operational Environmental System
PPF	Polar Platform
PPL	Preferred Parts List
PR	Preliminary Review
PROM	Programmable Read-Only Memory
PSK	Phase Shift Keying
PTV	Performance Test and Verification
P/L	Payload
QPL	Qualified Parts List
QPSK	Quadratic Phase Shift Keying
QSL	Quasi-Static Loads
RAM	Random Access Memory
RBI	Return Bus Interface
RCI	Reliability Critical Items
RET	Radiation Evaluation Test
RF	Radio Frequency
RFC	Radio Frequency Compatibility
RFI	Radio Frequency Interference
RHCP	Right Hand Circular Polarisation
ROM	Read Only Memory
RSSB	Remote Sensing Satellite Bus

RVT	Radiation Verification Test
R&S	Reliability & Safety
R-S	Reed-Solomon
ScaRaB	Scanner for Radiation Budget monitoring
SDE	Software Development Environment
SEM	Space Environment Monitor
SEU	Single Event Upset
SOW	Statement of Work
SRD	Software Requirements Document
SRDB	Satellite Reference Database
SRR	Systems Requirements Review
SSR	Solid State Recorder
SW	Software
S&R	Search and Rescue
TBC	To be confirmed
TBD	To be defined
TC	Telecommand
TM	Telemetry
TT&C	Telemetry, Tracking and Command
TWT	Travelling Wave Tube
UQPSK	Unsymmetrical Quadratic Phase Shift Keying
UTC	Universal Time Clock
VC	Virtual Channel
VCDU	Virtual Channel Data Unit
WBS	Work Breakdown Stimulation
WCRP	World Climate Research Programme
WPD	Work Package Description
YSM	Yaw Steering Mode

STATEMENT OF WORK AND TECHNICAL REQUIREMENTS

ANNEX H

FIGURES, FORMULAE AND DIAGRAMS

Prepared by: METOP Team

Checked by: R. Francis R. Francis 29/9/94

Approved by: P.G. Edwards 27.9.94

METOP Project Manager
Earth Observation Projects Department

Table of Contents

H1. ERROR DEFINITION AND COMPILATION METHOD FOR POINTING AND RATES

H1.1 SCOPE

This method is applicable for the behaviour of specified parameters which are not verified by direct measurement, but by a combination of test results, simulations and analysis. The specified values related to pointing accuracy of the relevant functional axes are defined in Annex A to the SOW. Contributing parameters to these specified values shall be governed by the content of this Annex.

H1.2 ERROR CHARACTERISATION FOR POINTING ERROR SOURCES

Error components e_i are classified according to their time dependence as follows:

- Bias Errors
  $e_i = b_i$ where e_i is a residual fixed offset error which is stable throughout the PPF mission by definition.
  Biases shall be assumed to have an uniform distribution such that $|bi|<B_i$.

- Drift Errors
  $e_i = d_i\ (T)$ where e_i is a variation due to ageing effects, which appears as a slow variation with time, but has no periodic character, with the possibility also of discrete steps.
  For the pointing budget drift contributions shall be taken with their worst value and treated as biases.

- Harmonic Errors
  $e_i = h_i \sin(2\pi t/T_i + \phi_i(t))$, where the period of oscillation T_i is normally of the order of the orbital or half orbital period. T_i may however be much smaller or much longer in some cases. The error has a mean of zero in that it does not contribute to bias error. The amplitude $h_i(t)$ and phase $\phi_i(t)$ may be drifting.
  For the pointing budget the worst $h_i(t)$ value, H_i shall be taken.

- Random Errors
  $e_i = r_i\ (t)$ where e_i is an unpredictable manner, relatively quickly in relation to an orbital period, in which there is no correlation between successive realisations.
  For the pointing budget these errors shall be assumed as having a Gaussian distribution with standard deviation σ_i.

H1.3 COMPILATION OF POINTING ERROR SOURCES

The following compilation method shall be applied:

- Bias and Drift Errors
  Biases and drifts shall be summed quadratically:
  $$b_t = \sqrt{\frac{4}{3}\sum_i B_i^2}$$
  However, if b_t is greater than ΣB_i, then $b_i = \Sigma B_i$.

- Harmonic Errors
  Harmonic errors shall be first summed linearly when having the same period, unless non-zero phasing can be demonstrated.
  $$h_{p_i} = \sum_i H_i$$

Afterwards they shall be summed quatratically:

$$h_t = \sqrt{2\sum_i h_{p_i}^2}$$

However, if h_t is greater than Σh_{pi}, then $h_t = \Sigma h_{pi}$.

- Random Errors
  Random errors shall be summed quadratically:

$$r_t = \sqrt{4\sum_i \sigma_i^2}$$

- Total Errors
  Total errors are either specified separately for biases, the combination harmonic and random, and for the overall combination of all categories.

Biases Total	=	b_t
Harmonic and Random Total	=	$(h_t^2 + r_t^2)^{1/2}$
Overall Total	=	$(b_t^2 + h_t^2 + r_t^2)^{1/2}$

- Calibration
  If possible, calibration will be used to reduce the effect of bias, drift and harmonic errors.
  The value of the concerned error then has to be replaced by the calibration error and the intercalibration interval residual error which must both be identified with their appropriate error classification. The error reduction actually achieved depends upon the calibration strategy.

  If calibration is not performed frequently enough and with sufficiently accurate references, aliasing and calibration errors will adversely affect the overall accuracy.

  Note: Aliasing errors are introduced when harmonic errors at the time of calibration cannot be differentiated from bias and drift errors.

H1.4 TRANSFORMATION OF ERRORS BETWEEN COORDINATE FRAMES

The resulting errors which are not given in the relevant antenna coordinate system must be transformed into this coordinate system.

Let an error in the satellite reference system be given through

$$\epsilon = \begin{bmatrix} \epsilon_{pitch} \\ \epsilon_{roll} \\ \epsilon_{yaw} \end{bmatrix}$$

and in the antenna reference system be given through

$$\theta = \begin{bmatrix} \theta_{azimuth} \\ \theta_{elevation} \\ \theta_{normal} \end{bmatrix}$$

The transformation matrix shall be A.

Now the pitch, roll and yaw errors have to be transformed separately into the antenna system, i.e.

$$\theta_1 = A\begin{bmatrix}\epsilon_{pitch}\\0\\0\end{bmatrix};\quad \theta_2 = A\begin{bmatrix}0\\\epsilon_{roll}\\0\end{bmatrix};\quad \theta_3 = A\begin{bmatrix}0\\0\\\epsilon_{yaw}\end{bmatrix}$$

and will in general result in errors in all three axes of the antenna system.

For a worst case consideration, the error in the antenna coordinate system will be given through

$$\theta_{azimuth} = |\theta_{1,az}| + |\theta_{2,az}| + |\theta_{3,az}|$$
$$\theta_{elevation} = |\theta_{1,el}| + |\theta_{2,el}| + |\theta_{3,el}|$$
$$\theta_{normal} = |\theta_{1,no}| + |\theta_{2,no}| + |\theta_{3,no}|$$

For a statistical consideration the error in the antenna coordinate system will be given through

$$\theta_{azimuth} = \sqrt{\theta_{1,az}^2 + \theta_{2,az}^2 + \theta_{3,az}^2}$$
$$\theta_{elevation} = \sqrt{\theta_{1,el}^2 + \theta_{2,el}^2 + \theta_{3,el}^2}$$
$$\theta_{normal} = \sqrt{\theta_{1,no}^2 + \theta_{2,no}^2 + \theta_{3,no}^2}$$

H1.5 RATE ERROR COMPILATION

The rate error of the PPF caused by the AOCS in the frequency range (f_1, f_2)

$$\omega_{3\sigma,} = \sqrt{9\int_{f_1}^{f_2} \Phi_\omega df + \sum_i \omega_i^2}$$

where ϕ_ω is the monolateral power spectral density of the deviation from nominal rate excluding periodic rate errors spectral lines. The entries w_i are discrete 3 σ periodic rate errors, with amplitudes w_i, e.g. caused by thermal distortions or by cyclic payload instruments torques.

If some cyclic errors have a known phase relation, this shall be used to determine the peak value for that set and this peak shall be considered as a single entry and combined with other errors via RSS in the manner shown.

H2. REFERENCE FRAMES

H2.1 SCOPE

This section defines the following reference frames:

- LOCAL ORBITAL REFERENCE FRAME
- LOCAL RELATIVE ORBITAL REFERENCE FRAME
- LOCAL RELATIVE YAW STEERING ORBITAL REFERENCE FRAME
- SATELLITE REFERENCE FRAME

- STRUCTURE REFERENCE FRAME
- PILOTING REFERENCE FRAME
- ATTITUDE REFERENCE FRAME
- SATELLITE OPTICAL REFERENCE FRAME
- ANTENNA LOCAL REFERENCE FRAMES
- INSTRUMENT OR ANTENNAS MOUNTING PLANE REFERENCE FRAMES
- INSTRUMENT OR ANTENNAS MIRROR CUBE REFERENCE FRAMES
- INSTRUMENT OPTICAL OR ELECTRICAL REFERENCE FRAMES
- LAUNCH VEHICLE REFERENCE FRAME

H2.2 LOCAL ORBITAL REFERENCE FRAME (T,R,L,)

The origin of the local orbital reference frame is the satellite in-flight centre of mass 'G'.

The unit vector $\underline{L}$ is in the direction opposite to the Earth's centre, [geocentre].

The unit vector $\underline{R}$ is perpendicular to $\underline{L}$ and in the vertical plane containing $\underline{V}$ such that cos ($\underline{V}$, $\underline{R}$) > 0, where $\underline{V}$ is the absolute velocity vector. The unit vector $\underline{T}$ completes the right-handed frame, ($\underline{T} = \underline{R} \times \underline{L}$).

This local orbital reference frame defines the absolute pointing of the satellite for the fine acquisition mode 1 and 2 with $\underline{T}$, $\underline{R}$, $\underline{L}$ being the pitch, roll and yaw axes respectively.

[$\underline{T}$: Tangage, $\underline{R}$: Roulis, $\underline{L}$: Lacet].

H2.3 LOCAL RELATIVE ORBITAL REFERENCE FRAME (T_1,R_1,L_1)

This Orbital Reference Frame is applicable to the fine pointing mode. It has the same definition as the Local Orbital Reference Frame ($\underline{T}$, $\underline{R}$, $\underline{L}$) except for the local normal pointing:

- The unit vector $\underline{L}$ is parallel to the Local normal of the earth's reference ellipsoid which shall be the WGS 84 model as defined in section 4.3.2.2. directed upward and crossing the spacecraft centre of mass 'G'.

This local relative orbital reference frame defines the absolute pointing of the satellite for the Fine Pointing Mode (FPM) with $\underline{T}_1$, $\underline{R}_1$, $\underline{L}_1$, being the pitch, roll and yaw axes respectively.

H2.4 LOCAL RELATIVE YAW STEERING ORBITAL REFERENCE FRAME (T', R', L')

This Orbital Reference Frame is applicable to the Yaw Steering Mode (YSM). It has the same definition as the Local Orbital Reference Frame ($\underline{T}$, $\underline{R}$, $\underline{L}$) except for the local normal pointing and for its orientation with respect to the spacecraft velocity vector:

- Local Normal Pointing $\underline{L'} = \underline{L}_1$
- The unit vector $\underline{R'}$ perpendicular to $\underline{L'}$ is in the direction of $\underline{V'}$ which is the velocity vector of the sub-satellite point relative to the earth model surface (relative ground trace velocity vector) taking

into account a place elliptical orbit with the orbital elements specified in Section 4.3.11.

This relative yaw steering orbital reference frame defines the absolute pointing of the satellite for the yaw steering mode with T', R' L' being the pitch, roll and yaw axes respectively.

H2.5 SATELLITE REFERENCE FRAME (X_S, Y_S, Z_S)

The origin is on the centre line of the spacecraft at its intersection with the satellite/launcher adaptor interface plane. The X_s axis coincides with the longitudinal (downward vertical) axis of the satellite on the launch vehicle. The Z_s axis coincides with the outward normal to the surface carrying the stowed solar array, and the Y_s axis forms a right handed orthogonal set.

In orbit, when the satellite is being yaw steered (see Annex 2), the satellite orientation shall be such that the $-Z_s$ axis is aligned close the downward local normal (Nadir), the $-Y_s$ axis is aligned close to the ground track velocity direction and the $-X_s$ axis is such that ($-X_S$, $-Y_S$, $-Z_S$) form a right handed orthogonal set. Note $-X_s$ is close to the negative orbit pole.

H2.6 STRUCTURE REFERENCE FRAME (X_{ST}, Y_{ST}, Z_{ST})

This frame is derived from the satellite reference frame by a 180° rotation about the Z_s - axis such that

$X_{ST} = -X_S$

$Y_{ST} = -Y_S$

$Z_{ST} = -Z_S$

H2.7 PILOTING REFERENCE FRAME ($X_{PIL}, Y_{PIL}, Z_{PIL}$)

The Piloting reference frame to which the attitude control is performed. The angles between the unit vectors of the reference frame (X_A, Y_A, Z_A) and the local relative yaw steering orbital reference frame (T', R', L') are the pointing errors due to the ABCS in yaw steering mode (YSM) after an 180° rotation around the spacecraft Z_A axis (i.e. positive pitch and roll errors in the attitude reference frame are negative w.r.t. the local relative yaw steering orbital reference frame).

The origin of the frame is the satellite centre of mass. The approximate direction of the Piloting frame axes are:

Pitch axis parallel to $X_{PIL} = +X_s$

Roll axis parallel to $Y_{PIL} = +Y_s$

Yaw axis parallel to $Z_{PIL} = +Z_s$

This frame is characterised with respect to a satellite mirror cube, the Satellite Optical Reference.

H2.8 ATTITUDE REFERENCE FRAME (X_A, Y_A, Z_A)

The Attitude Reference Frame (X_A, Y_A, Z_A) is that frame to which the attitude measurement is performed.

This frame is obtained by Translation of the Piloting Reference Frame ($X_{PIL}, Y_{PIL}, Z_{PIL}$) origin to the position of the AOCS optical sensor which ensures the AOCS performances.

H2.9 SATELLITE OPTICAL REFERENCE FRAME (X_{SO}, Y_{SO}, Z_{SO})

The satellite optical reference frame is defined by a reference mirror cube located at a stable position on the payload module. It shall remain visible throughout the AIT phase and pre-launch check out. A secondary reference mirror cube shall also be installed as a back-up. The unit vectors along (X_{SO}, Y_{SO}, Z_{SO}) shall be nominally parallel, ad in the same sense to the unit vectors along (X_S, Y_S, Z_S). This reference frame shall be used for payload and satellite level alignments.

H2.10 ANTENNA LOCAL REFERENCE FRAMES ($X_{ANT}, Y_{ANT}, Z_{ANT}$)

The antenna local reference frame is specific to each antenna and there is a fixed relation between this reference frame and the nominal electrical characteristics of an antenna.

H2.11 INSTRUMENT OR ANTENNAS MOUNTING PLANE REFERENCE FRAMES ($X_{AMP}, Y_{AMP}, Z_{AMP}$)

This frame is defined for each physically separated unit (or antenna) which composes the instrument.
The origin of the frame is the center of the Reference datum point which is physically represented by the centre of the mounting hole in the reference lug. One couple of axes will lie on the datum plane, defined as the plane of the instrument unit lugs.
The axes of the INSTRUMENT OR ANTENNAS MOUNTING PLANE REFERENCE FRAME ($X_{AMP}, Y_{AMP}, Z_{AMP}$) shall be nominally parallel to the SATELLITE REFERENCE FRAME (X_S, Y_S, Z_S).

H2.12 INSTRUMENT OR ANTENNAS MIRROR CUBE REFERENCE FRAMES ($X_{AMC}, Y_{AMC}, Z_{AMC}$)

For each instrument or antenna the mirror cube frame shall be realised through a mirror cube located near the mounting plane of the instrument/antenna.

The axes of the instrument/antenna mirror cube frame shall be nominally parallel to the axes of the satellite optical reference frame.

H2.13 INSTRUMENT OPTICAL OR ELECTRICAL REFERENCE FRAMES (X_I, Y_I, Z_I)

These observation frames are derived from Optical or RF measurements on instruments or antennas and relate the achieved optical axis or electrical pattern of an antenna with respect to an instrument or antenna local reference frame.

The alignment of the Instrument Optical or electrical reference frame with respect to the Piloting reference frame is achieved through the Satellite Optical reference frame ad the Instrument or antennas mirror cube reference frames.

H2.14 LAUNCH VEHICLE REFERENCE FRAME (X_L, Y_L, Z_L)

This is defined in the ARIANE 4 and ARIANE 5 Manual (see Annex A).

H3. FINE POINTING AND YAW STEERING MODES DEFINITION

The yaw steering mode will be the routine attitude pointing mode for the satellite.

The fine pointing mode will be the intermediate attitude pointing mode between fine acquisition and Yaw Steering Mode (YSM) for the satellite. The fine pointing and yaw steering mode commanded reference frame are derived from the fine acquisition mode command reference frame. In fine acquisition mode the commanded reference is defined as follows:

- Zsg is aligned with the direction from the Earth centre to the satellite centre of mass.
- Ysg is in the orbit plane perpendicular to Zsg closely aligned to the velocity vector direction.
- $\underline{Xsg} = \underline{Ysg} \wedge \underline{Zsg}$

Where Xsg, Ysg, Zsg is the satellite reference frame translated to the actual satellite centre of mass.

The fine pointing mode provide the following change to the fine acquisition mode:

The Zsg axis (yaw) is aligned to the local normal (outward direction) of the Earth reference ellipsoid. This modification is also implemented in fine pointing mode.

The yaw steering mode provide the following change to the fine pointing mode:

Compensation of Earth rotation effects is achieved by yaw steering the satellite so that the satellite roll axis projected on the tangential plane on the earth model surface at the geodetic sub-satellite point coincides with the projected relative velocity vector (relative ground trace velocity vector) between the geodetic sub-satellite point and the earth model surface.

The local relative orbital reference frame and the local relative yaw steering orbital reference frame applicable for the control law are defined in para H2.3 and H2.4.

The rotation about the Xsg (pitch), Ysg (roll) and Zsg (yaw) axis to obtain the fine pointing and yaw steering mode commanded reference frames are given hereafter:

(Only the first two rotations are necessary to obtain the fine pointing mode).

First rotation "roll" command about +Ysg

$$\Delta\eta = -e_e^2 \frac{a_e}{a} \sin i \cos i \sin\alpha$$

The roll correction is of orbital frequency with zero value at the ascending and descending nodes with the maximum positive value at highest northern latitude and the maximum negative value at highest southern latitude. The amplitude is small compared to the pitch correction.

Second rotation "pitch" command about +Ysg

$$\Delta\xi = -e_e^2 \frac{a_e}{a} \sin^2 i \frac{\sin 2\alpha}{2}$$

The pitch correction is of bi-orbital frequency. The value is negative between the ascending node and the highest northern latitude ad between the descending node ad the highest southern latitude. It is positive between the highest northern latitude and the descending node and between the highest southern latitude and the ascending node.

Third rotation "yaw" command about +Zsg

$$\Delta\zeta = \arctan\left(\frac{\sin i \cos\alpha}{N-\cos i}\right)$$

The yaw correction is of orbital frequency and is positive on the ascending orbit pass, negative on the descending pass and zero at the highest northern and southern latitudes

With:

e_e	=	fe (s-f_e), eccentricity of earth ref. ellipsoid
fe	=	1/298.257223563 oblateness of earth ref. ellipsoid
a_e	=	6378.137 (Km), semi-major axis of earth ref. ellipsoid
a	=	mean orbit semi-major axis = 7197.939472 km.
i	=	mean orbit inclination = 98.704663 deg.
α	=	orbital angle (α = 0 at the ascending node and α = W + V where W is the mean argument of perigee and V the mean true anomaly)
N	=	number of orbits per day = 14 + 1/5.

H4. ASCAT DEFINITIONS

H4.1 WIND MODE DEFINITIONS

The performances of the ASCAT system can be split into two groups, the spatial and the radiometric performances.

For both, the definitions and calculations of parameters are based on the radar cross section estimate, σ^0, defined by:

$$\hat{\sigma}^0(x_0,y_0) = \frac{S(x_0,y_0)}{\int_y\int_x IRF_{x_0,y_0}(x,y)\,dx\,dy}$$

where (S(x,y) is the radar output signal, proportional to the received echo power, and $IRF_{x0,y0}$ (x,y) is the Impulse Response Function described below.

The following definitions of performance parameters apply to each of the 3 beams (otherwise specified) for each node in a swath around the orbit for the mission lifetime of the instrument.

H4.1.1 The Spatial Performances

These performances are determined by the geometrical form of the IRF and its dependence on the satellite pointing error. The following IRF parameters are defined in the principal cut in each of the along track and across track directions only:

- *Impulse Response Function (IRF)*

  The impulse response function $IRF_{x0,y0}$ (x,y) is specified as the two-dimensional response to a point target, at position x_0, y_0, such that the effects of background clutter and thermal noise can be neglected, x and y are the along and across track coordinates measured on the surface of the earth reference ellipsoid.

- *Spectral Resolution*

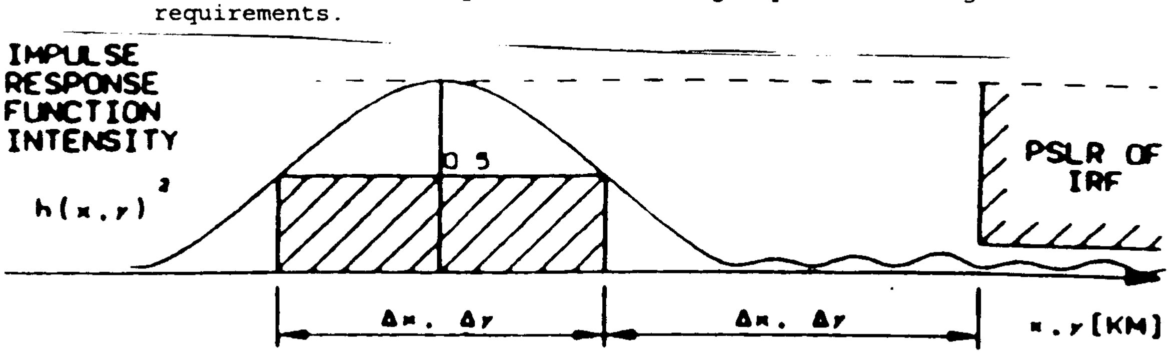
  The two-dimensional spectral resolution is given by the width of the system modulation transfer function, where the spectral intensity reaches 50% of the peak value. The Modulation Transfer Function, $MTF_{x0,Y0}$ (X,Y), is specified as the Fourier transform of the IRF, at frequencies X0, Y0, where X and Y are the spatial frequencies of the MTP in the along and across track cuts, and are expressed in km^{-1}.

- *Spatial Resolution*

  The two-dimensional spatial resolution (resolution, cell) is defined in the principal cut in each of the along and across track directions, as the width of the overall system impulse response function (IRF), where the intensity reaches 50% of the peak value (3 dB-width).

- *Peak Sidelobe Ration of IRF*

  The peak sidelobe ratio (PSLR) of the IRF is specified as the ratio of the maximum value of the IRF to the highest level at any point spaced more than one resolution cell distant (Fig. H4-1). The PSLR shall be compatible with ambiguity and aliasing requirements.



Δx - spatial resolution along track
Δy - spatial resolution across track

Fig. H4-1 : Definition of PSLR of IRF

- *Ambiguity Contribution to the Radiometric Resolution*

The uncertainties due to ambiguities (ϵ_{AM}) are derived from the scenario in Fig. H4-2. This describes the disturbance to a σ^0 estimate due to areas of high reflectivity outside the node region. The reflecting area is defined as a "well" of size 200 km along track and 150 km across track, with σ^0 inside the "well" centre incidence angle with 4m/s crosswind (i.e. minimum value) and σ^0 = 10 log (cos θ_i) outside the "well".
The ambiguous contributions are defined by:

$$\varepsilon_{AM} = \frac{ambiguous \cdot energy \cdot contribution \cdot from \cdot outside \cdot the \cdot well}{energy \cdot from \cdot well}$$

- *Aliasing Contributions*

This describes the disturbance to a σ^0 estimate due to a non-uniform spatial distribution of the reflectivity field. The uncertainties due to aliasing effects (ϵ_{AL}) shall be based on a uniform spectrum of target fluctuations.
The aliasing contributions are defined by:

$$\varepsilon_{AL} = \frac{\Delta\sigma^0 \cdot from \cdot outside \cdot nonalias \cdot region}{\Delta\sigma^0 \cdot from \cdot inside \cdot nonalias \cdot region}$$

Where $\Delta\sigma^0$ represents the contribution to the σ^0 estimate and the aliased contributions at a point in the swath are those arising from received spatial frequencies outside a rectangular area (non-aliasing region) of sides $\pm 1/50 km^{-1}$ centred on the two-dimensional spectrum at the point.

- *Dynamic Range*

The dynamic range is specified as the range of σ^0 levels of a uniform distributed target over which the performance requirements applied.

- *Localisation Accuracy*

This is defined as the maximum error in the estimate of the position of a point target, determined by the point equidistant between the -3 dB points of its impulse response measured in along and across track cuts, separately for each beam.

- *Mid Swath Inclination Angle*

Throughout the orbit, the instrument shall maintain a constant inclination angle at mid swath (i.e. at the central node of the 19 nodes array).
This angle is defined such that the incidence angle at the nearest boundary of the cell surrounding the first node (i.e. 25 km closer to the satellite ground track than the first node) is 25 degrees when the satellite is at its lowest altitude.

- *Swath Width*

The full performance swath width is the across-track ground range over which the performance specification shall be met by the final σ^0 product. The reduced performance swath width is the across-track ground range over which the ASCAT collects data.

In the wind processor on ground, a weighting function is applied to the set of instrument measurement data in order to meet the spatial and spectral resolution requirements. The measurement data covered by the weighting function arises from a large scattering area on ground, and data from outside the full performance swath is utilised to form the outer nodes of the full performance swath. However, the in-orbit performance requirements need to be met for all nodes of the full performance swath.

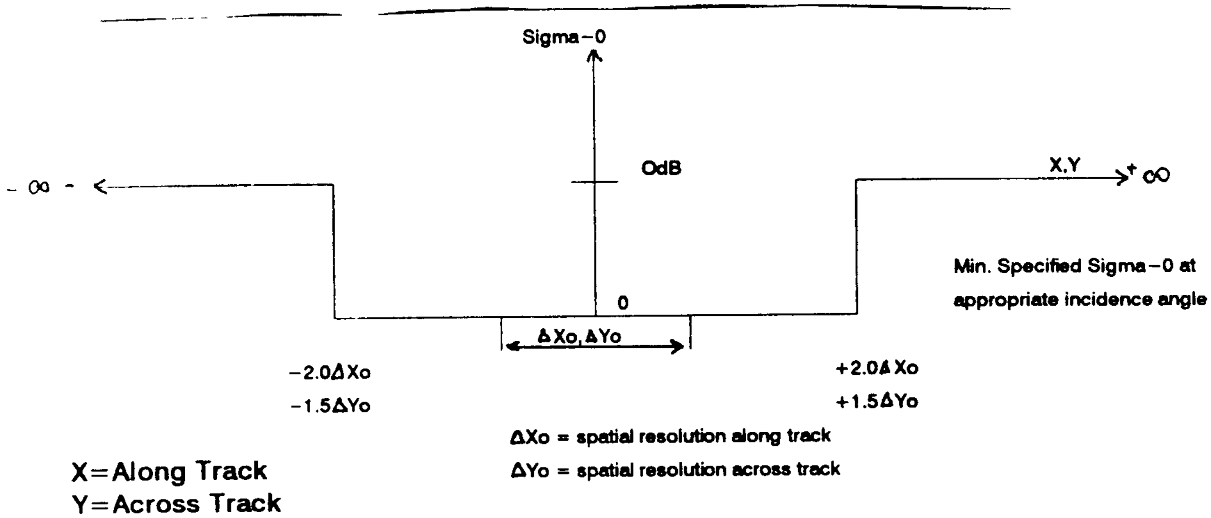


Fig. H4-2 : Ambiguity Scenario

4.1.2 The Radiometric Performances

These performances are determined by instrument parameters like antenna gain, noise figures, calibration accuracy and stability of sub-system parameters. They are characterised by the following parameters:

- *Radiometric Resolution*

The radiometric resolution K_p, is specified as the ability of the ASCAT to resolve between different values of radar backscatter coefficient. It describes the uncertainty in a σ^0 estimate due to speckle and thermal noise. It is defined as the normalised standard deviation of a σ^0 estimate:

$$K_p = \sqrt{E\left(\frac{\hat{\sigma}^0}{\sigma^0} - \frac{E(\hat{\sigma}^0)}{\sigma^0}\right)^2}$$

where E is the expectation operator, $\hat{\sigma}^0$ is the σ^0 is the estimate and σ^0 is the true value.

- *Radiometric Accuracy*

  This describes the uncertainty in a σ^0 estimate when the speckle and the thermal noise are neglected. It is split into the bias, defined as the average variation of normalised σ^0 estimates with respect ot true values per beam and per node index (across swath) and the stability, defined as the rms variation around the bias.

- *Interbeam Radiometric Stability*

  The interbeam radiometric stability is defined as the maximum permissible relative difference in the σ^0 estimate, assuming averaging over speckle and thermal noise, between any pair of beams.

- *Cross Polarisation*

  It is defined for that part of the antenna far field pattern bounded by the two-way half power beamwidth in the across-range direction and by the full performance swath in the across-track direction.
  The peak components of the electric field vector in a place containing the satellite local vertical and the direction of propagation has a magnitude E_0. The peak components of the electrical field of view observed in a plane orthogonal to this, which contains the direction of propagation has a magnitude E_x. The Cross Polarisation, x is defined as (in dB):

$$x = 20 \cdot \log \frac{E_0}{E_x}$$